Volume 15 JULY-AUGUST, 1950 Number 4

Food Research

Under the Editorial Guidance of

Z. I. KERTESZ SAMUEL C. PRESCOTT L. B. JENSEN

Heureux déjà d' avoir pu servir mes concitoyens et l' humanite, je me repose sur la justice, la générosité et les lumières d' un gouvernement sage qui ne cesse d' encourager et de protéger toutes les découvertes utiles.

—NICOLAS APPERT.

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Food Research

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KEEPING FAITH WITH NATURE
NOW...MILLED WHITE RICE CAN MEET
MODERN NUTRITIONAL DEMANDS
Nutritionists, Government authorities and cereal processors the world over will, we believe, welcome this Hoffmann-La Roche news. For until peoples of the great rice-eating nations can enjoy a state of health free from beriberi and other effects of malnutrition, world trade and security will be deprived of a most essential guarantee. A nation cannot be BOTH productive and happy without good health. Now it can be both even if its people's principal staple food is milled white rice.
Enrichment of wheat flour, macaroni products and corn meals was a relatively simple problem which Hoffmann-La Roche chemists and technical experts were pleased to help solve. However, the popular practice of washing or rinsing rice before cooking renders the usual type of enriching premix useless since the vitamin content dissolves in the water and is lost. As a leader in world production of vitamins, Hoffmann-La Roche looked for a means of hurdling this difficulty, found it, and its patented processes have been made available to the rice milling industry.
Going further, and to demonstrate conclusively that addition of lacking vitamins and minerals to a staple food cereal was a practicable and easy means of correcting dietary deficiencies, Hoffmann-La Roche joined with four other participants in making possible the greatest nutritional experiment* of all time. Involving 100,000 Philippine people, this experiment has furnished proof with which flour millers, bakers and other cereal processors can overcome the "doubting Thomases" of "enrichment."
Ask to see, and if you eat rice insist upon being served, the new "nutritionally improved" milled white rice carrying thiamine, niacin and iron at the same minimum per pound levels as enriched white wheat flour and corn products.
*The experiment is under the joint auspices of the Williams-Waterman Fund, Republic of the Philippines Department of Health, United States Public Health Service Rehabilitation Program, National Rice and Corn Corporation of the Philippines and Hoffmann-La Roche Inc. Preliminary reports published thus far have appeared in the Journal of Nutrition of August 1949, Journal of the Philippine Medical Association, November 1949, and the Rice Journal of April, 1950.
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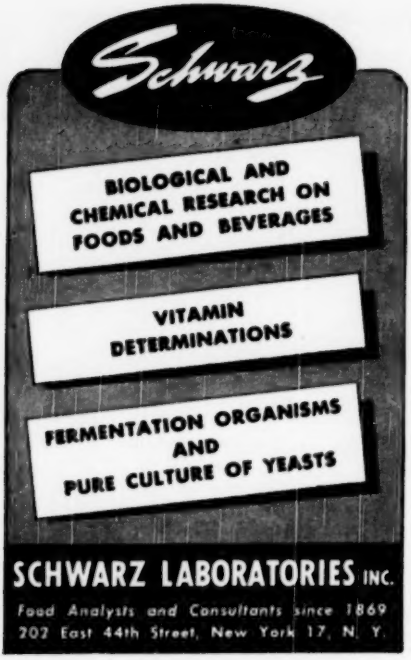
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COMPOSITION OF FOOD PLANTS OF CENTRAL AMERICA. IV. EL SALVADOR

HAZEL E. MUNSELL, LOUIS O. WILLIAMS, LOUISE P. GUILD, CYNTHIA B. TROESCHER, GERTRUDE NIGHTINGALE, LUCILLE T. KELLEY, AND ROBERT S. HARRIS

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[Received for publication, February 20, 1950]

This paper is the fourth of a series which gives results from a study begun in 1946 to obtain data on the composition of edible plants from the countries of Central America. The first three reports show results from analyses of 121 samples from Honduras, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1949); and 230 samples from Guatemala, Munsell *et al.* (1950a and b). Data from the analyses of 194 samples collected in El Salvador between September, 1946 and the middle of June, 1949 are presented in this paper.

The samples were collected and prepared for shipment according to the procedures described in the first paper, Munsell *et al.* (1949). Three slurries were made of all except 70 samples, which were staple foods, and were shipped without treatment. The constituents measured were the same as those shown in the previous reports, and no significant change was made in the methods of analysis beyond the modification for measuring ascorbic acid, already noted in Paper II of the series.

A majority of the samples, 155, was obtained in markets, chiefly in Santa Tecla or San Salvador. The remaining 39 samples were taken directly from the ground or obtained near where they grew, from the person who had produced or collected them. The samples are probably more representative of foods grown in the central and south-central areas of El Salvador than of other regions of the country. Information on soil type, estimated annual rainfall, and number of samples collected in the various areas is shown (Table 1). Because the altitude varied significantly over areas where many of the samples originated, the information on altitude is given (Table 2) with the other data for each sample.

The 194 samples analyzed represent 108 different foods; for 52 of these there were more than one sample.

DESCRIPTIONS AND USES OF FOODS STUDIED[1]

EARTH VEGETABLES:

Camote (I, *Camote*). The specimens of both samples of the sweet potato had purple skins. The flesh of those of Sample (a) was pale orange-yellow and that of Sample (b) cream color. Both samples were purchased in the Santa Tecla market.

[1] Description of some of the foods has already been given in one of the earlier reports. This is indicated by a notation in parenthesis giving the series number for the reference as follows: I, Munsell *et al.* (1949); II, Munsell *et al.* (1950a); III, Munsell *et al.* (1950b), and the name of the food under which the description is given.

TABLE 1

Areas Where Samples Originated, With Information on Prevailing Soil Type and Estimated Annual Rainfall

Code No.	Town	Department	Soil type	Estimated rainfall	No. of samples
				in.	
1	Apopa	San Salvador	Volcanic	60-70	4
2	Ateos	La Libertad	Volcanic	50	2
3	Chilamatal	La Libertad	Volcanic	50	1
4	Cojutepeque	Cuscatlán	.....	50	1
5	Colón	La Libertad	Volcanic	50-80	8
6	Cuscatlán Bridge	Between Usulatán and San Vicente	Sand; gravel	30	1
7	El Matasano near Santa Tecla	La Libertad	Volcanic	70	1
8	Entre Ríos	Sonsonate	Volcanic	50	1
9	Ilopango	San Salvador	Volcanic	50	1
10	La Cumbre near Santa Tecla	La Libertad	Volcanic	50-70	4
11	La Joya	Santa Ana	Volcanic	70	2
12	La Junta near Santa Tecla	La Libertad	Volcanic	70	1
13	Las Moras near Santa Tecla	La Libertad	Volcanic	60	1
14	Los Amates near Santa Tecla	La Libertad	Volcanic	.....	1
15	Los Planes de los Renderos	San Salvador	Volcanic	70-80	3
16	Mejicanos	San Salvador	Volcanic	60	3
17	Plan de Laguna	San Salvador	Volcanic	70	1
18	Puerto de Laguna	San Salvador	Volcanic	50	1
19	Puerto de La Libertad	La Libertad	Outwash plain	30	3
20	San Andrés C.N.A.	La Libertad	Volcanic	60	8
21	San Miguel	San Miguel	Volcanic	40	1
22	San Pedro	Cuscatlán	Volcanic	60	1
23	San Salvador	San Salvador	Volcanic	60	15
24	San Vicente	San Vicente	Volcanic	60	2
25	Santa Ana	Santa Ana	Volcanic	60	10
26	Santa Tecla	La Libertad	Volcanic	50-100	30
27	Santa Tecla, C.N.A.	La Libertad	Volcanic	60	10
28	Santo Tomás	San Salvador	Volcanic	70	2
29	Sonsonate	Sonsonate	Volcanic	50-70	15
30	Talpa	Sonsonate	Sandy	40	1
31	Tonocatepeque	San Salvador	Volcanic	100	1
32	Volcán de San Salvador	San Salvador and La Libertad	Volcanic	50-100	45
33	Volcán de Santa Ana	Santa Ana	Volcanic	.....	1
34	Volcán de San Vicente	San Vicente	Volcanic	.....	1
35	Zaragoza	La Libertad	Alluvial	.....	2

Cebolla (I, *Cebolla*). The cool tropical highlands of Central America are congenial to the growth of the onion, and several varieties of the common onion are grown and appreciated. They are to be found in most markets of the highland area throughout the year, although they are relatively expensive. Most onions seen are of the type that can be eaten green. Both

samples were grown near Santa Ana. Sample (a), purchased in the Santa Tecla market, was a mixed lot of bulbs having rather strong-flavored white flesh and mostly white skins, although a few were red. Sample (b), purchased in San Salvador, was made up of small, mature bulbs with white skins.

Jícama (I, *Jícama*). The yam bean is cultivated in most tropical regions for its large, watery root. It is seen occasionally in markets in Central America but is not common. The peeled root may be used in soups or stews but it is more commonly eaten raw. Samples (a) and (b) were purchased in the market; Samples (c) and (d) were taken from experimental plots at the Centro Nacional de Agronomía. Sample (a) consisted of large roots; Sample (b) of medium-sized ones, and Samples (c) and (d) of five mature roots each. Flesh only was used in the prepared samples.

Nabo (II, *Nabo*). The sample of turnip was purchased in the Santa Tecla market and consisted of 25 small, mature specimens. These were peeled and quartered for subsampling.

Ñame. Yams are not cultivated commonly in Central America, and have not been seen on sale in any market. Specimens of the two samples analyzed were collected at the Centro Nacional de Agronomía. Sample (a) consisted of 15 white-fleshed roots, some of which were small. Sample (b) consisted of 10 large roots, the flesh of which was quite purple. Prepared samples were made from transverse sections, peeled and diced.

Papa. The sample of *papa* and Sample (a) of *papa blanca* were purchased in the Santa Tecla market; Sample (b) of *papa blanca* in a San Salvador market. The sample of *papa* consisted of two pounds of medium-sized potatoes, Sample (a) of *papa blanca* of 26 small ones, and Sample (b) of *papa blanca* of 15 medium-sized ones. For the prepared samples the potatoes were peeled and diced.

Rábano (I, *Rábano*). Both samples of radishes were purchased in the San Salvador market but at different times of the year. Sample (a) consisted of about 200 roots, varying in size from large to small and having red skins and generally white flesh. Sample (b) comprised 20 round, red, mature roots, some of which were very large, albeit firm and not pithy. Skin and pulp were used in the prepared samples.

Remolacha (II, *Remolacha*). Sample (a) consisted of 12 mature beets purchased from an Indian who grew them, and Sample (b) of 10 small beets taken from an experimental plot at the Centro Nacional de Agronomía. Prepared samples were made from peeled roots.

Yuca (I, *Yuca*). Samples (a) and (b) of cassava were purchased in the Santa Tecla market; the sample of *yuca corriente* was taken from a plot at the Centro Nacional de Agronomía. Sample (a) consisted of 24 small roots with firm, white flesh, Sample (b) of 10 selected roots, and the sample of *yuca corriente* of three large roots and one small one taken from the ground. For the prepared samples the peel and the thin layer directly beneath were discarded.

Zanahoria (I, *Zanahoria*). Sample (a) of carrots comprised 24 mature roots with greenish tops, which were obtained where they grew. Sample (b) consisted of 12 mature roots taken from a plot at the Centro Nacional

TABLE 2

Composition of Food Samples From El Salvador

Name of food sampled			Place of origin and altitude[1]		Constituents measured and yields per 100 gm.												
Spanish	Scientific	English			Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid total
	EARTH VEGETABLES		*Code No.*	*ft.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Camote	*Ipomoea Batatas* (L.) Lam.	Sweet potato	32	4,000	73.2	0.11	1.1	.230	.88	20.8	33.9	0.87	.289	.128	.043	.658	37.0
Camote morado	*Ipomoea Batatas* (L.) Lam.	Sweet potato	25	3,000	79.0	0.20	0.6	.066	.58	15.4	27.2	0.77	.024	.068	.019	.288	24.6
Cebolla	*Allium Cepa* L.	Onion	25	3,000	89.1	0.03	0.7	.278	.48	16.7	51.7	1.30	.007	.054	.033	.386	9.4
Cebolla	*Allium Cepa* L.	Onion	25	1,500	87.3	0.06	0.6	.225	.45	20.4	49.4	0.51	.003	.044	.043	.332	8.0
Jícama (a)	*Pachyrrhizus erosus* (L.) Urban	.....	16	2,200	87.0	0.12	0.8	.190	.42	14.0	14.1	1.55	.002	.052	.036	.220	3.6
Jícama (b)	*Pachyrrhizus erosus* (L.) Urban	.....	5	2,500	89.3	0.25	0.5	.137	.28	8.9	16.4	0.31	.005	.025	.026	.299	21.7
Jícama (c)	*Pachyrrhizus erosus* (L.) Urban Hort. var. *Martínez*	.....	20	1,700	83.7	0.07	0.6	.242	.42	21.6	20.8	0.51	.004	.050	.036	.350	38.4
Jícama (d)	*Pachyrrhizus erosus* (L.) Urban Hort. var. *Santa Ana*	.....	20	1,700	83.0	0.06	0.5	.249	.51	23.0	24.2	0.56	.003	.052	.032	.331	32.5
Nabo	*Brassica Rapa* L.	Turnip	32	3,200	93.4	0.09	0.9	.114	.77	46.6	25.9	0.51	.003	.034	.020	.907	26.8
Ñame (a)	*Dioscorea alata* L.	Yam	20	1,700	73.5	0.25	0.5	.311	.87	4.5	51.4	0.57	.000	.127	.015	.452	10.1
Ñame (b)	*Dioscorea alata* L.	Yam	20	1,700	78.7	0.26	0.4	.364	.74	2.5	50.3	0.52	.000	.102	.014	.566	11.6
Papa	*Solanum tuberosum* L.	Potato	25	2,200	83.1	0.26	0.5	.263	.73	5.1	52.9	0.50	.000	.074	.023	1.343	30.0
Papa blanca (a)	*Solanum tuberosum* L.	Potato	25	3,000	85.1	0.11	0.3	.262	.83	7.3	55.3	1.26	.007	.108	.018	1.053	28.4
Papa blanca (b)	*Solanum tuberosum* L.	Potato	25	3,000	80.1	0.04	0.4	.312	1.05	6.3	72.4	0.49	.006	.100	.035	1.630	24.0
Rábano (a)	*Raphanus sativus* L.	Radish	32	4,000	94.0	0.09	0.7	.150	.79	28.8	17.6	1.37	.003	.031	.029	.272	37.6
Rábano (b)	*Raphanus sativus* L.	Radish	32	5,000	95.0	0.07	0.5	.123	.74	19.4	32.7	0.64	.005	.017	.022	.206	26.5
Remolacha (a)	*Beta vulgaris* var. *crassa* Alef.	Beet	32	5,500-6,000	86.2	0.03	0.8	.174	.67	13.6	19.0	2.01	.004	.006	.021	.223	4.1
Remolacha (b)	*Beta vulgaris* var. *crassa* Alef.	Beet	27	3,200	84.6	0.06	0.7	.294	.75	17.1	39.2	0.63	.002	.023	.064	.331	4.9
Yuca (a)	*Manihot esculenta* Crantz.	Cassava	5	3,000	60.5	0.18	0.9	.080	.96	19.8	43.5	0.65	.003	0.54	.022	.665	50.6

Yuca (b)	*Manihot esculenta* Crantz.	Cassava	8	1,000	68.3	0.14	1.3	.265	1.10	29.1	78.2	0.56	.007	.059	.039	.532	20.8
Yuca corriente	*Manihot esculenta* Crantz.	Cassava	20	1,700	67.6	0.25	0.5	.132	1.04	27.0	67.8	0.40	.014	.072	.031	.698	46.2
Zanahoria (a)	*Daucus Carota L.*	Carrot	32	5,500	91.8	0.03	0.8	.057	.84	25.7	23.3	0.33	.575	.035	.025	.380	9.6
Zanahoria (b)	*Daucus Carota L.*	Carrot	27	3,200	89.2	0.06	0.8	.169	.94	38.1	42.5	0.78	4.232	.057	.048	.955	10.1
	HERBAGE VEGETABLES																
Acapate	*Eryngium foetidum* L.	.....	18	2,500	85.7	0.66	2.0	.373	2.07	295.0	45.8	5.73	3.795	.090	.215	.963	28.0
Agria	*Hibiscus Sabadariffa* L.	Roselle	20	1,700	88.1	0.17	1.0	.140	.75	156.4	36.6	2.26	.007	.017	.052	.373	15.7
Apio	*Apium graveolens* L.	Celery	15	3,000	93.5	0.09	0.7	.117	1.30	65.9	48.2	1.06	.003	.031	.049	.286	11.0
Berro	*Nasturtium officinale* R. Br.	Watercress	25	2,000	94.7	0.19	0.6	.378	.92	77.9	41.9	3.39	.707	.076	.102	.864	34.6
Chipilín (a)	*Crotalaria longirostrata* Hook. & Arn.	.....	32	5,500	80.0	0.74	2.2	1.179	1.41	270.8	75.2	3.52	9.710	.378	.409	1.730	48.3
Chipilín (b)	*Crotalaria longirostrata* Hook. & Arn.	.....	32	3,500-4,500	81.1	1.11	1.7	1.202	1.50	233.8	88.2	3.52	11.878	.357	.546	1.927	149.4
Chipilín (c)	*Crotalaria longirostrata* Hook. & Arn.	.....	26	3,000	87.0	0.51	1.2	.889	.98	104.3	74.7	2.43	.018	.264	.418	1.285	48.6
Chufle	*Calathea macrosepala* Schumann	.....	26	3,500	92.3	0.24	1.5	.287	1.27	20.2	48.6	0.98	.010	.037	.101	.741	7.3
Espinaca (a)	*Tetragonia expansa* Thunb.	New Zealand ice plant	32	5,000	93.0	0.35	0.7	.393	1.14	65.5	31.8	3.85	2.810	.027	.177	.403	28.2
Espinaca (b)	*Tetragonia expansa* Thunb.	New Zealand ice plant	27	3,200	91.0	0.32	0.7	.380	1.91	74.8	22.0	4.87	2.432	.021	.154	.550	34.7
Izote, cogollo de (a)	*Yucca elephantipes* Regel	Yucca hearts	32	2,000-4,000	89.3	0.38	1.4	.190	1.89	370.0	31.6	0.77	.005	.107	.032	.359	34.0
Izote, cogollo de (b)	*Yucca elephantipes* Regel	Yucca hearts	26	4,000	91.2	0.19	0.8	.101	1.87	313.3	15.8	1.01	.005	.280	.040	.234	16.9
Izote, flor de (a)	*Yucca elephantipes* Regel	Yucca flowers	11	3,000	81.6	0.34	0.9	.310	.99	25.3	66.1	2.44	.028	.169	.155	1.680	560.0
Izote, flor de (b)	*Yucca elephantipes* Regel	Yucca flowers, perianth	26	3,500	86.2	0.27	0.7	.254	.88	39.4	59.8	1.08	.019	.128	.160	1.541	400.0
Izote, flor de (c)	*Yucca elephantipes* Regel	Yucca flowers, ovary	26	3,500	82.4	0.22	1.4	.410	1.05	39.2	85.5	0.60	.144	.196	.139	1.225	292.5
Lechuga (a)	*Lactuca sativa* L. var. *romana* Hort.	Lettuce	32	6,000	95.4	0.21	0.6	.146	.85	57.3	25.6	1.65	.124	.057	.071	.384	9.4

TABLE 2 (*Continued*)

Composition of Food Samples From El Salvador

Name of food sampled			Place of origin and altitude[1]		Constituents measured and yields per 100 gm.												
Spanish	Scientific	English			Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid total
			Code No.	ft.	gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Lechuga (b)	*Lactuca sativa* L. var. *romana* Hort.	Lettuce	1	6,000	94.4	0.24	0.7	.204	.92	51.2	30.6	1.10	1.100	.079	.102	.370	26.5
Loroco	*Fernaldia pandurata* (A.DC.) Woodson	Flowers of fiddle-shaped Fernaldia	32	3,000	90.3	0.16	1.3	.343	1.03	43.2	41.4	1.02	.093	.387	.102	2.240	10.3
Madre de cacao	*Gliricidia sepium* (Jacq.) Walp.	Madre	5	1,700	85.7	0.15	1.2	.408	.61	17.1	38.4	2.62	.137	.128	.076	.665	42.7
Mora (a)	*Solanum nigrum* L.	.....	32	2,000-3,000	84.4	0.76	2.0	.795	1.87	202.2	67.9	11.67	.824	.186	.316	.746	60.8
Mora (b)	*Solanum nigrum* L.	.....	32	4,000	86.7	0.69	1.1	.740	1.62	240.5	56.4	7.30	.055	.168	.330	.838	50.0
Motate (a), (see also Pollita)	*Bromelia Pinguin* L.	.....	26	2,000-3,000	91.6	0.40	0.8	.147	1.14	124.2	22.9	0.64	.005	.027	.044	.400	23.2
Motate (b), (see also Pollita)	*Bromelia Pinguin* L.	.....	1	3,500	93.0	0.17	0.9	.358	1.22	158.0	50.1	0.34	.017	.034	.090	.567	34.3
Pacaya	*Chamaedorea graminifolia* Wendl.	.....	34	2,000-3,000	85.3	0.25	1.1	.764	2.35	474.5	122.7	1.49	.014	.112	.106	1.220	12.4
Palmito de coyol	*Acrocomia mexicana* Karw.	Palm cabbage	19	100	87.6	0.44	0.7	.378	1.24	156.9	58.6	1.04	.006	.041	.079	1.260	20.2
Perejil	*Petroselinum crispum* (Mill.) Mansfeld	Parsley	29	600	84.1	0.65	1.5	.637	2.40	258.0	47.8	2.98	2.217	.178	.284	1.164	222.5
Pito, (see also Quilite)	*Erythrina Berteroana* Urban	.....	32	4,000	82.9	0.28	2.7	.720	1.33	78.0	85.1	1.80	.310	.208	.186	1.225	43.0
Pollita, (see also Motate)	*Bromelia Pinguin* L.	.....	1	1,600	92.5	0.21	0.4	.141	1.07	107.3	25.6	0.51	.008	.029	.041	.382	19.2
Quilite, (see also Pito)	*Erythrina Berteroana* Urban	.....	26	3,000	86.6	0.31	2.1	.879	1.17	87.7	85.6	3.24	2.173	.209	.159	1.099	18.1
Repollo (a)	*Brassica oleracea* var. *capitata* L.	Cabbage	32	5,500	93.8	0.09	0.6	.190	.46	31.1	18.7	0.42	.010	.035	.038	.206	39.2
Repollo (b)	*Brassica oleracea* var. *capitata* L.	Cabbage	27	3,200	92.6	0.02	0.5	.191	.53	36.7	18.4	0.28	.016	.042	.037	.216	51.7

Yuca, hojas de	*Manihot esculenta* Crantz.	Cassava leaves	20	1,700	73.4	1.56	2.3	1.430	2.43	269.3	171.3	12.78	.683	.259	.400	3.080	420.0
	FRUIT VEGETABLES																
Aguacate (a)	*Persea americana* Mill.	Avocado	5	2,000	84.5	6.37	2.1	.301	1.19	17.9	50.0	0.91	.188	.057	.114	.999	17.6
Aguacate (b)	*Persea americana* Mill.	Avocado	10	3,500	79.8	12.37	1.8	.184	1.04	13.8	28.5	0.43	.034	.067	.096	1.568	14.0
Aguacate (c)	*Persea americana* Mill.	Avocado	26	3,000	80.5	10.49	1.4	.279	.97	7.3	44.3	0.72	.075	.097	.135	1.112	15.6
Aguacate (d)	*Persea americana* Mill.	Avocado	26	3,000	85.4	7.51	1.1	.278	.72	10.4	35.6	0.52	.030	.053	.139	2.220	11.5
Aguacate (e)	*Persea americana* var. *drymifolia* (Schlecht. & Cham.) Blake	Avocado	26	3,000	82.1	9.89	1.2	.228	.87	3.6	36.0	0.85	.041	.061	.118	1.645	12.0
Berenjena (a)	*Solanum Melongena* var. *esculentum* (Dunal) Nees	Eggplant	32	3,500	92.0	0.02	0.9	.148	.48	8.9	32.8	1.52	.061	.068	.031	.578	7.2
Berenjena (b)	*Solanum Melongena* var. *esculentum* (Dunal) Nees	Eggplant	32	4,000	92.0	0.07	0.9	.191	.56	4.6	33.8	0.91	.005	.063	.033	.653	6.7
Berenjena (c)	*Solanum Melongena* var. *esculentum* (Dunal) Nees	Eggplant	27	3,100	90.4	0.09	0.9	.190	.62	11.9	34.0	0.40	.007	.070	.039	.818	8.0
"Chilacayote"	*Cucurbita ficifolia* Bouché	.....	32	5,000	94.1	0.02	0.4	.128	.67	9.2	18.7	0.58	.002	.057	.018	.273	1.6
Chile cieruela	*Capsicum annuum* var. *longum* (DC.) Sendt.	.....	32	4,000	91.5	0.23	1.2	.198	.65	9.7	20.2	0.34	.007	.053	.052	1.184	32.4
Chile dulce, (see also Chile verde)	*Capsicum annuum* var. *grossum* (L.) Sendt.	Sweet pepper	32	4,000	93.3	0.07	1.0	.102	.41	6.3	19.9	0.67	.063	.027	.022	.510	110.0
Chile pepino	*Capsicum annuum* var. *cerasiforme* Irish	Hot pepper	26	3,000	77.2	2.02	8.0	.527	1.39	26.3	69.4	1.12	1.083	.188	.164	2.634	87.2
Chile picante (a)	*Capsicum annuum* var. *conoides* (Miller) Irish	Hot pepper	25	3,000	90.1	0.57	1.2	.161	.62	9.8	21.0	0.85	.905	.045	.106	1.116	84.4
Chile picante (b)	*Capsicum annuum* var. *longum* (DC.) Sendt.	Hot pepper	27	3,200	91.0	0.20	1.1	.198	.57	4.4	32.2	0.75	.099	.050	.060	1.021	275.0
Chile verde, (see also Chile dulce)	*Capsicum annuum* var. *grossum* (L.) Sendt.	Sweet pepper	29	1,000	90.9	0.19	1.2	.183	.45	6.1	28.7	0.61	.289	.082	.038	.844	115.0
Cuchamper (a)	*Vincetoxicum Salvinii* (Hemsl.) Standl.	.....	32	5,500	93.2	0.14	0.7	.142	.37	10.0	12.8	0.61	.009	.047	.016	.217	118.1
Cuchamper (b)	*Vincetoxicum Salvinii* (Hemsl.) Standl.	.....	32	3,000-4,000	91.3	0.06	1.0	.225	.50	12.5	21.1	0.33	.012	.148	.028	.238	171.9
Güisayote	*Sechium edule* (Jacq.) Sw.	Chayote	26	3,500	89.7	0.26	0.7	.227	.40	12.6	38.4	0.49	.022	.026	.041	.685	21.8
Güisquil	*Sechium edule* (Jacq.) Sw.	Chayote	32	4,000-5,000	93.7	0.08	0.4	.135	.37	7.7	26.8	0.32	.008	.019	.028	.281	19.5

TABLE 2 (*Continued*)

Composition of Food Samples From El Salvador

Name of food sampled			Place of origin and altitude[1]		Constituents measured and yields per 100 gm.											
Spanish	Scientific	English	Code No.	ft.	Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid total
					gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Huisquil	*Sechium edule* (Jacq.) Sw.	Chayote	23	4,000	91.9	0.10	0.5	.109	.35	10.2	26.5	0.84	.003	.018	.030	.399	29.0
Pepino	*Cucumis sativus* L.	Cucumber	32	4,000	96.3	0.03	0.3	.086	.37	10.1	25.8	0.28	.002	.026	.017	.137	9.8
Pipián (a)	*Cucurbita Pepo* L.	Summer squash	32	3,000-4,000	92.8	0.22	0.4	.142	.52	15.5	31.7	0.55	.027	.059	.030	.480	20.2
Pipián (b)	*Cucurbita Pepo* L.	Summer squash	25	4,000	91.4	0.11	0.4	.203	.53	14.7	37.1	0.77	.055	.060	.055	.544	26.8
Pipián (c)	*Cucurbita Pepo* L.	Summer squash	26	3,000	91.9	0.22	0.4	.147	.43	21.0	33.0	0.48	.086	.041	.041	.677	19.1
Pipián (d)	*Cucurbita Pepo* L.	Summer squash	1	2,000	94.3	0.01	0.3	.083	.36	17.3	27.6	0.69	.001	.053	.027	.264	13.5
Tomate	*Lycopersicum esculentum* Mill.	Tomato	26	3,200	94.2	0.24	0.7	.145	.46	2.9	18.9	2.07	.289	.067	.029	.680	30.5
Tomate chapadón	*Lycopersicum esculentum* Mill.	Tomato	26	3,000	94.4	0.13	0.6	.111	.51	6.8	29.1	0.37	.419	.060	.030	.484	29.2
Tomate de jugo	*Lycopersicum esculentum* Mill.	Tomato	27	3,200	93.2	0.20	0.6	.177	.61	4.2	32.0	0.50	.423	.101	.062	.649	36.3
Tomate Jocote	*Lycopersicum esculentum* Mill.	Tomato	23	4,000	94.5	0.40	0.7	.101	.72	12.3	40.1	1.96	.421	.078	.033	.527	32.8
Tomatillo	*Lycopersicum esculentum* var. *cerasiforme* (Dunal) Hort.	Cherry tomato	26	3,000	91.0	0.42	1.9	.221	.81	20.7	47.9	0.46	1.558	.127	.088	.679	58.5
	CEREALS																
Elote (a)	*Zea Mays* L.	Corn, green	32	4,000	69.5	1.21	3.4	.664	.82	1.8	128.5	1.14	.004	.191	.100	2.535	3.4
Elote (b)	*Zea Mays* L.	Corn, green	26	3,500	62.0	1.28	0.9	.683	.72	0.4	121.0	0.60	.007	.154	.067	2.040	10.9
Elote (c)	*Zea Mays* L.	Corn, green	5	2,500	64.1	1.48	1.0	.647	.75	2.2	133.4	0.58	.010	.128	.075	2.562	9.4
Elote (d)	*Zea Mays* L.	Corn, green	9	1,800	62.6	1.28	1.3	.704	.79	3.1	133.3	0.62	.021	.190	.090	1.948	10.8
Elote de apante	*Zea Mays* L.	Corn, green	2	2,000	60.1	1.51	0.8	.796	.88	6.0	156.2	0.94	.001	.173	.079	1.791	6.3
Maíz de apante	*Zea Mays* L.	Corn, green	12	2,800	59.8	1.31	0.8	.748	.75	2.1	125.0	0.71	.012	.203	.089	2.090	6.2
Masa de tortillas	*Zea Mays* L.	Dough for tortillas	26	.....	63.6	1.07	0.3	.528	.47	21.5	99.8	1.00	.006	.109	.052	.935	0.1

	LEGUMES															
Cujin, (see also Guajiniquil)	*Inga Preussii* Harms	.....	5	2,500	85.9	0.06	0.8	.136	.31	15.3	16.9	0.73	.004	.042	.048	.311	5.7
Ejote (a)	*Vigna unguiculata* (L.) Walp.	Cowpea, green	15	2,200	89.2	0.10	1.2	.412	.59	47.0	47.4	0.80	.011	.116	.097	.862	27.8
Ejote (b) (frijolito tierno)	*Phascolus vulgaris* L.	Green snapbean	32	4,000	91.5	0.13	1.1	.280	.60	39.9	46.4	1.56	.066	.073	.081	.540	8.0
Ejote (c)	*Phascolus vulgaris* L.	Green snapbean	31	3,000	92.6	0.07	0.9	.312	.57	42.5	37.9	0.79	.188	.072	.084	.494	12.7
Ejote (d)	*Phascolus vulgaris* L.	Green snapbean	23	2,000	92.1	0.08	0.6	.319	.52	41.8	33.2	0.62	.021	.083	.091	.452	16.4
Ejote de seda	*Phascolus vulgaris* L.	Green snapbean	29	700	88.2	0.09	1.2	.452	.65	42.1	62.1	1.07	.418	.078	.093	.744	13.0
Frijol negro	*Phascolus vulgaris* L.	Black bean, shell	23	.....	54.1	0.12	2.1	1.950	1.93	62.4	309.3	2.94	.004	.423	.085	1.640	4.8
Frijol tierno	*Phascolus vulgaris* L.	Bean, shell	28	2,500	70.1	0.38	1.5	1.309	1.20	46.7	113.4	2.63	.039	.280	.155	2.622	37.7
Guajiniquil, (see also Cujin)	*Inga Preussii* Harms	.....	32	3,000-6,000	78.4	0.14	1.1	.213	.50	9.9	30.8	1.54	.007	.061	.069	.400	14.8
Paterno (a)	*Inga Paterno* Harms	(Aril)	26	3,000	83.0	0.19	0.9	.161	.28	12.0	20.0	0.63	.003	.056	.056	.543	7.8
Paterno (b)	*Inga Paterno* Harms	(Seeds)	26	3,000	65.1	0.16	0.9	1.476	.84	39.9	83.2	1.04	.011	.148	.112	1.105	28.5
Pepeto	*Inga leptoloba* Schlecht.	.....	26	3,000	77.7	0.06	1.3	.146	.37	16.8	20.1	1.45	.008	.034	.057	.297	6.5
	FRUITS															
	1. Citrus															
Mandarina	*Citrus reticulata* Blanco	Tangerine	29	600	88.3	0.05	0.3	.091	.29	27.8	11.7	0.17	.039	.058	.026	.223	41.8
Naranja	*Citrus sinensis* (L.) Osbeck	Orange	25	3,000	89.4	0.09	0.3	.105	.37	30.8	17.2	2.01	.004	.072	.017	.213	47.2
Naranja agria	*Citrus Aurantium* L.	Sour orange	27	3,200	83.1	0.05	1.8	.167	.57	64.3	19.6	0.85	.055	.059	.030	.282	55.2
Naranga lima	*Citrus limetta* Risso	Sweet lime	26	3,000	92.4	.....[2]	...[2]	.051	.25	0.9	8.9	0.61	.004	.013	.011	.114	34.8
Toronja	*Citrus maxima* (Burm.) Merrill	Grapefruit	26	3,000	89.5	0.06	0.0	.060	.32	16.6	16.7	0.55	.047	.031	.013	.163	49.8
	2. Bananas															
Banano de seda	*Musa paradisiaca* var. *sapientum* L.	Banana	10	4,000	72.0	0.10	3.2	.245	1.48	5.8	30.3	0.42	.151	.035	.051	.652	8.5
Banano Patriota	*Musa paradisiaca* var. *sapientum* L.	Banana	10	2,400	73.4	0.27	0.2	.161	.86	5.5	25.5	0.62	.006	.033	.065	.826	9.4
Guineo colorado	*Musa paradisiaca* var. *sapientum* L.	Banana	32	3,000-4,000	72.9	0.44	0.4	.200	.76	9.9	16.3	0.87	.061	.028	.034	.550	5.6

Name of food adopted			Edible portion of 100 parts as purchased		Water	Protein	Fat	Ash	Fiber	Carbohydrates	Calcium	Phosphorus	Iron	Vitamin A	Vitamin B	Vitamin C	Calories
			Number	g	%	%	%	%	%	%	mg	mg	mg				
Guineo manzano	*Musa paradisiaca* var. *sapientum* L.	Plátano	32	4,000	65.7	1.30	0.4	0.90	0.5	31.2	10.0	30.0	0.60	0.15	0.05	0.10	128.0
Guineo morado	*Musa paradisiaca* var. *sapientum* L.	Red plantain	28	3,500	70.1	0.97	0.3	0.85	0.5	27.4	8.0	25.0	0.50	0.12	0.04	0.08	112.0
	3. Plantains																
Guineo criollo	*Musa paradisiaca* L.	Plantain	32	5,500	68.3	0.95	0.3	1.80	0.5	28.2	9.0	28.0	0.55	0.08	0.04	0.05	118.0
Guineo morado	*Musa paradisiaca* L.	Red plantain	30	4,800	70.5	0.85	0.3	0.95	1.00	26.4	8.5	26.5	0.52	0.10	0.04	0.06	110.0
Majoncho (a)	*Musa paradisiaca* L.	Plantain	30	5,000	68.0	0.92	0.3	1.90	0.5	28.4	9.5	29.0	0.58	0.09	0.04	0.05	120.0
Majoncho (b)	*Musa paradisiaca* L.	Plantain	28	4,200 5,000	69.0	0.95	0.3	1.70	0.5	27.5	9.0	27.0	0.55	0.08	0.04	0.05	115.0
	4. Other																
Amarra	*Vitis tiliifolia* Humb. & Bonpl.	Wild grape	12	1,000	80.5	0.55	0.3	0.65	0.8	17.2	6.0	18.0	0.30	0.05	0.02	0.03	72.0
Anona blanca	*Annona diversifolia* Safford	Ilama	32	5,000	73.5	0.70	0.3	0.75	1.20	23.5	7.0	21.0	0.40	0.04	0.03	0.02	96.0
Anona rosada	*Annona reticulata* L.	Bullock's heart	30	5,000	69.5	0.80	0.6	0.85	1.50	26.8	8.0	24.0	0.45	0.06	0.03	0.02	108.0
Caimito	*Chrysophyllum Caimito* L.	Star apple	20	3,000	80.1	0.50	0.3	0.60	1.0	17.5	5.0	15.0	0.25	0.03	0.02	0.01	72.0
Capulin	*Muntingia Calabura* L.		25	1,500	77.8	1.20	1.0	1.10	1.5	17.4	12.0	30.0	0.80	0.10	0.05	0.03	84.0
Capulin Montés	*Saurauia pauciserrata* Hemsl.		32	4,000	83.1	0.81	0.5	0.70	1.0	13.9	10.0	26.0	0.60	0.08	0.04	0.02	72.0
Chuste, (see also Chupte)	*Persea Schiedeana* Nees		8	2,000	59.3	2.30	1.8	0.95	0.6	35.0	30.0	50.0	0.85	0.04	0.10	0.06	192.0
Chupte	*Persea Schiedeana* Nees		32	4,000	57.0	2.55	1.0	1.05	1.0	37.5	35.0	55.0	0.95	0.05	0.12	0.07	208.0
Ciruela corona	*Spondias purpurea* L.	Red mombin	25	2,000	80.2	0.40	0.2	0.50	1.10	17.6	6.0	14.0	0.20	0.02	0.01	0.01	68.0
Coco (a)	*Cocos nucifera* L.	Coconut	20	1,000	50.3	34.00	0.4	1.03	1.10	9.3	107.5	1.70	0.03	0.10	0.05	0.02	354.0
Coco (b)	*Cocos nucifera* L.	Coconut	33	100	51.4	34.50	0.5	1.01	0.9	11.0	11.5	1.10	0.04	0.11	0.06	0.03	360.0
Coco, leche de	*Cocos nucifera* L.	Coconut milk	33	100	93.1	0.09	0.1	0.80	0.3	10.0	0.8	0.10	0.01	0.02	0.01	0.01	44.0

Durazno (a)	*Prunus persica* (L.) Sieb & Zucc.	Peach	32	4,000	85.1	0.59	0.8	.139	.72	13.7	20.3	1.37	.015	.023	.029	.327	23.2
Durazno (b)	*Prunus persica* (L.) Sieb & Zucc.	Peach	32	5,000	84.2	0.07	1.0	.129	.84	8.0	26.9	0.44	.008	.036	.025	.294	10.0
Granadilla	*Passiflora ligularis* Juss.	Sweet granadilla	32	5,000-6,000	79.1	2.61	4.2	.340	1.06	5.6	56.2	1.56	.005	.000	.072	1.237	10.8
Granadilla de fresco	*Passiflora quadrangularis* L.	Giant granadilla	7	3,200	94.4	0.15	0.7	.112	.41	13.8	17.1	0.80	.004	.000	.033	.378	14.5
Granadilla para refrescos	*Passiflora quadrangularis* L.	Giant granadilla	26	3,000	78.4	1.29	3.6	.299	.80	9.2	39.3	2.93	.019	.003	.120	1.897	15.3
Guanábana	*Annona muricata* L.	Guanabana	11	1,500	84.1	0.26	0.8	.109	.49	21.0	23.7	0.32	.004	.080	.052	.746	24.3
Guayaba perulera	*Psidium Guajava* L.	Guava	32	3,000-4,000	84.9	0.37	4.5	.131	.51	15.1	22.5	1.39	.013	.037	.032	.800	43.0
Guinda	*Phyllanthus acidus* (L.) Skeels	Otaheite gooseberry	23	3,000	91.9	0.52	0.8	.155	.51	5.4	17.9	3.25	.019	.025	.013	.292	4.6
Huiscoyol	*Bactris subglobosa* Wendl.	.....	19	200	81.8	0.13	1.5	.239	1.44	23.2	33.0	1.51	.345	.028	.055	.319	9.1
Icaco	*Chrysobalanus Icaco* L.	Icaco	30	0	89.4	0.03	0.8	.078	.66	23.9	17.8	0.44	.007	.047	.032	.420	10.6
Icaco morado	*Chrysobalanus Icaco* L.	Icaco	24	1,000	85.9	0.15	1.1	.083	.73	22.2	17.2	0.81	.....	.035	.053	.405	8.3
Mamey (a)	*Mammea americana* L.	Mamey	26	2,800	85.7	0.15	0.9	.085	.21	13.2	12.0	0.92	.043	.017	.025	.160	12.0
Mamey (b)	*Mammea americana* L.	Mamey	29	2,000	86.3	0.09	1.1	.074	.20	10.2	12.7	0.27	.156	.023	.039	.496	11.0
Mamey (c)	*Mammea americana* L.	Mamey	29	1,000	85.0	0.99	1.2	.059	.12	9.1	7.8	0.15	.250	.024	.036	.416	22.0
Mamey (d)	*Mammea americana* L.	Mamey	29	750	85.9	0.09	0.8	.050	.18	19.5	10.5	0.23	.178	.018	.033	.410	15.3
Mamón	*Melicocca bijuga* L.	.....	21	300	92.5	0.02	0.1	.091	.38	6.6	23.9	0.47	.044	.021	.020	.659	3.1
Mango	*Mangifera indica* L.	Mango	26	3,000	83.3	0.04	0.8	.079	.44	8.0	17.9	0.26	1.872	.033	.049	.483	91.3
Mango corriente	*Mangifera indica* L.	Common mango	26	2,000	83.2	0.11	0.4	.057	.37	9.4	7.8	0.32	.004	.028	.032	.440	107.2
Mango verde	*Mangifera indica* L.	Green mango	29	600	86.4	0.08	0.8	.118	.33	18.6	14.4	0.25	.025	.034	.026	.208	172.0
Marañón (a)	*Anacardium occidentale* L.	Cashew apple	29	2,000	85.8	0.10	0.6	.149	.33	1.5	19.3	0.67	.240	.023	.015	.480	146.6
Marañón (b)	*Anacardium occidentale* L.	Cashew apple	16	2,000	88.7	0.05	0.4	.125	.28	1.8	19.9	0.19	.022	.015	.013	.478	231.3
Marañón japonés (a)	*Eugenia malaccensis* L.	.....	26	3,200	91.2	0.20	0.7	.074	.26	5.9	11.6	0.82	.003	.023	.020	.320	15.3
Marañón japonés (b)	*Eugenia malaccensis* L.	.....	26	3,000	90.3	0.04	0.8	.102	.39	5.6	17.9	0.20	.008	.039	.032	.291	6.5
Marañón japonés (c)	*Eugenia malaccensis* L.	.....	26	3,000	91.6	0.06	0.6	.110	.30	5.6	16.3	0.37	.006	.027	.029	.360	17.0

TABLE 2 (*Continued*)

Composition of Food Samples From El Salvador

Name of food sampled			Place of origin and altitude[1]		Constituents measured and yields per 100 gm.												
Spanish	Scientific	English			Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid total
			Code No.	ft.	gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Guineo manzano	*Musa paradisiaca* var. *sapientum* L.	Banana	32	4,000	65.5	0.23	0.4	.209	.83	4.9	41.8	0.65	.015	.027	.020	.850	19.0
Guineo morado	*Musa paradisiaca* var. *sapientum* L.	Red banana	19	100	71.1	0.07	0.3	.238	.82	9.4	17.7	0.40	.012	.048	.042	.676	12.0
	3. Plantains																
Guineo criollo	*Musa paradisiaca* L.	Plantain	32	3,500	73.0	0.03	0.1	.185	.81	4.4	33.3	0.54	.166	.042	.021	.398	21.2
Guineo morado	*Musa paradisiaca* L.	Red plantain	10	4,000	70.5	0.07	0.4	.204	1.03	11.2	22.6	0.52	.377	.041	.046	.559	8.2
Majoncho (a)	*Musa paradisiaca* L.	Plantain	32	3,000-4,000	73.6	0.22	0.6	.160	.74	7.7	42.3	1.03	.009	.042	.026	.500	14.8
Majoncho (b)	*Musa paradisiaca* L.	Plantain	28	2,000	65.6	0.07	0.4	.174	.82	6.9	25.6	0.37	.060	.062	.038	.547	20.7
	4. Other																
Ama uva	*Vitis tiliifolia* Humb. & Bonpl.	Wild grape	17	2,200	80.5	0.13	4.6	.185	.79	95.1	43.5	0.86	.025	.027	.044	.142	7.8
Anona blanca	*Annona diversifolia* Safford	Ilama	32	5,000	71.5	0.16	1.3	.447	1.37	31.6	51.7	0.70	.011	.235	.297	2.177	13.6
Anona rosada	*Annona reticulata* L.	Bullock's heart	29	2,000	68.3	0.10	6.6	.371	.96	21.4	24.4	0.45	.007	.075	.086	.528	41.2
Caimito	*Chrysophyllum Cainito* L.	Star apple	26	3,000	80.1	3.16	3.3	.220	.72	22.0	21.1	0.63	.039	.020	.014	.888	3.0
Capulín	*Muntingia Calabura* L.	.....	27	3,100	77.8	1.56	4.6	.324	1.14	124.6	84.0	1.18	.019	.065	.037	.554	80.5
Capulín Montés	*Saurauia pauciserrata* Hemsl.	.....	32	4,000	83.4	0.37	1.3	.112	.79	65.0	32.4	0.48	.060	.012	.029	.252	12.5
Chucte, (see also Chupte)	*Persea Schiedeana* Nees	.....	5	2,000	76.5	7.59	1.8	.204	.91	12.5	36.2	0.31	.033	.070	.089	.598	16.4
Chupte	*Persea Schiedeana* Nees	.....	32	4,000	77.6	5.55	1.0	.191	.72	11.4	35.5	0.35	.003	.048	.067	.718	5.7
Ciruela corona	*Spondias purpurea* L.	Red mombin	23	2,000	69.5	0.16	0.6	.152	1.13	23.9	55.2	1.22	.073	.094	.049	1.676	73.0
Coco (a)	*Cocos nucifera* L.	Coconut	29	1,000	52.5	31.50	2.4	.724	1.15	5.5	107.1	1.78	.004	.048	.026	.712	8.2
Coco (b)	*Cocos nucifera* L.	Coconut	35	100	81.4	11.86	0.7	.361	.82	11.0	41.7	1.10	.002	.054	.028	.812	6.6
Coco, leche de	*Cocos nucifera* L.	Coconut milk	35	100	95.1	0.06	....[2]	.036	.38	19.8	6.6	0.38	.000	.002	.008	.036	1.5

Durazno (a)	*Prunus persica* (L.) Sieb & Zucc.	Peach	32	4,000	85.1	0.59	0.8	.139	.72	13.7	20.3	1.37	.015	.023	.029	.327	23.2
Durazno (b)	*Prunus persica* (L.) Sieb & Zucc.	Peach	32	5,000	84.2	0.07	1.0	.129	.84	8.0	26.9	0.44	.008	.036	.025	.294	10.0
Granadilla	*Passiflora ligularis* Juss.	Sweet granadilla	32	5,000-6,000	79.1	2.61	4.2	.340	1.06	5.6	56.2	1.56	.005	.000	.072	1.237	10.8
Granadilla de fresco	*Passiflora quadrangularis* L.	Giant granadilla	7	3,200	94.4	0.15	0.7	.112	.41	13.8	17.1	0.80	.004	.000	.033	.378	14.5
Granadilla para refrescos	*Passiflora quadrangularis* L.	Giant granadilla	26	3,000	78.4	1.29	3.6	.299	.80	9.2	39.3	2.93	.019	.003	.120	1.897	15.3
Guanábana	*Annona muricata* L.	Guanabana	11	1,500	84.1	0.26	0.8	.109	.49	21.0	23.7	0.32	.004	.080	.052	.746	24.3
Guayaba perulera	*Psidium Guajava* L.	Guava	32	3,000-4,000	84.9	0.37	4.5	.131	.51	15.1	22.5	1.39	.013	.037	.032	.800	43.0
Guinda	*Phyllanthus acidus* (L.) Skeels	Otaheite gooseberry	23	3,000	91.9	0.32	0.8	.155	.51	5.4	17.9	3.25	.019	.025	.013	.292	4.6
Huiscoyol	*Bactris subglobosa* Wendl.	.....	19	200	81.8	0.13	1.5	.239	1.44	23.2	33.0	1.51	.345	.028	.055	.319	9.1
Icaco	*Chrysobalanus Icaco* L.	Icaco	30	0	89.4	0.03	0.8	.078	.66	23.9	17.8	0.44	.007	.047	.032	.420	10.6
Icaco morado	*Chrysobalanus Icaco* L.	Icaco	24	1,000	85.9	0.15	1.1	.083	.73	22.2	17.2	0.81	.....	.035	.053	.405	8.3
Mamey (a)	*Mammea americana* L.	Mamey	26	2,800	85.7	0.15	0.9	.085	.21	13.2	12.0	0.92	.043	.017	.025	.160	12.0
Mamey (b)	*Mammea americana* L.	Mamey	29	2,000	86.3	0.09	1.1	.074	.20	10.2	12.7	0.27	.156	.023	.039	.496	11.0
Mamey (c)	*Mammea americana* L.	Mamey	29	1,000	85.0	0.99	1.2	.059	.12	9.1	7.8	0.15	.250	.024	.036	.416	22.0
Mamey (d)	*Mammea americana* L.	Mamey	29	750	85.9	0.09	0.8	.050	.18	19.5	10.5	0.23	.178	.018	.033	.410	15.3
Mamón	*Melicocca bijuga* L.	.....	21	300	82.5	0.02	0.1	.091	.38	6.6	23.9	0.47	.044	.021	.020	.659	3.1
Mango	*Mangifera indica* L.	Mango	26	3,000	83.3	0.04	0.8	.079	.44	8.0	17.9	0.26	1.872	.033	.049	.483	91.3
Mango corriente	*Mangifera indica* L.	Common mango	26	2,000	83.2	0.11	0.4	.057	.37	9.4	7.8	0.32	.004	.028	.032	.440	107.2
Mango verde	*Mangifera indica* L.	Green mango	29	600	86.4	0.08	0.8	.118	.33	18.6	14.4	0.25	.025	.034	.026	.208	172.0
Marañón (a)	*Anacardium occidentale* L.	Cashew apple	29	2,000	85.8	0.10	0.6	.149	.33	1.5	19.3	0.67	.240	.023	.015	.480	146.6
Marañón (b)	*Anacardium occidentale* L.	Cashew apple	16	2,000	88.7	0.05	0.4	.125	.28	1.8	19.9	0.19	.022	.015	.013	.478	231.3
Marañón japonés (a)	*Eugenia malaccensis* L.	.....	26	3,200	91.2	0.20	0.7	.074	.26	5.9	11.6	0.82	.003	.023	.020	.320	15.3
Marañón japonés (b)	*Eugenia malaccensis* L.	.....	26	3,000	90.3	0.04	0.8	.102	.39	5.6	17.9	0.20	.008	.039	.032	.291	6.5
Marañón japonés (c)	*Eugenia malaccensis* L.	.....	26	3,000	91.6	0.06	0.6	.110	.30	5.6	16.3	0.37	.006	.027	.029	.360	17.0

TABLE 2 *(Continued)*

Composition of Food Samples From El Salvador

Name of food sampled			Place of origin and altitude[1]		Constituents measured and yields per 100 gm.												
Spanish	Scientific	English			Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid total
			Code No.	ft.	gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Matasano	*Casimiroa edulis* Llave & Lex.	.....	26	3,000	78.3	0.03	0.9	.143	.48	9.9	20.4	0.33	.053	.042	.043	.472	30.3
Melón	*Cucumis Melo* L.	Melon	6	100	92.0	0.10	0.7	.199	.62	14.2	18.5	0.41	.200	.033	.029	1.028	29.8
Mora (a)	*Rubus glaucus* Benth.	"Loganberry"	32	4,500	86.6	0.19	2.3	.139	.47	22.1	25.6	1.51	.010	.023	.024	.553	14.6
Mora (b) (frambuesa)	*Rubus glaucus* Benth.	"Loganberry"	32	5,000	82.4	0.24	4.2	.184	.53	26.2	34.0	1.63	.010	.030	.029	.947	14.4
Nance (a) (nancito)	*Byrsonima crassifolia* (L.) DC.	.....	23	4,000	79.3	1.83	2.7	.121	.69	36.8	14.6	1.01	.060	.013	.038	.297	192.0
Nance (b)	*Byrsonima crassifolia* (L.) DC.	.....	29	1,000	80.5	1.38	2.5	.109	.58	31.0	15.7	0.62	.035	.014	.039	.266	90.0
Níspero (a)	*Manilkara Zapotilla* (Jacq.) Gilly	Sapodilla	32	4,000	77.4	1.53	1.7	.046	.40	30.3	8.0	1.39	.036	.001	.006	.147	17.0
Níspero (b)	*Manilkara Zapotilla* (Jacq.) Gilly	Sapodilla	29	700	74.3	0.97	1.6	.064	.34	25.2	9.7	0.39	.012	.002	.007	.184	7.6
Papaturros	*Coccoloba caracasana* Meisn.	.....	2	2,000	74.6	0.18	1.8	.320	.80	54.1	46.8	1.52	.010	.026	.031	.347	16.9
Papaya	*Carica Papaya* L.	Papaya	29	1,000	86.9	0.96	1.3	.087	.53	17.8	17.5	0.34	.208	.036	.043	.326	57.5
Papaya verde	*Carica Papaya* L.	Papaya, green	27	3,200	91.6	0.05	0.8	.120	.57	40.8	22.0	0.26	.004	.035	.036	.239	35.5
Pepino	*Solanum muricatum* Ait.	Pepino	32	6,000	90.1	0.05	0.4	.066	.26	4.4	13.8	1.25	.015	.057	.030	.280	36.7
Piña	*Ananas comosus* (L.) Merrill	Pineapple	26	3,000	82.2	0.07	0.5	.068	.34	12.5	8.9	0.85	.014	.103	.039	.267	40.7
Piña azucarón	*Ananas comosus* (L.) Merrill	Pineapple	15	1,800	83.8	0.03	0.5	.069	.35	8.6	9.1	0.29	.031	.103	.036	.201	43.3
Piña de Castilla	*Ananas comosus* (L.) Merrill	Pineapple	22	2,000	82.5	0.27	0.4	.094	.43	14.9	9.1	0.36	.055	.080	.029	.159	78.6
Pinuela (a)	*Bromelia Karatas* L.	.....	26	3,400	87.4	0.32	0.3	.238	.87	52.8	8.0	0.69	.015	.067	.026	.370	56.3
Pinuela (b)	*Bromelia Karatas* L.	.....	16	2,000	86.8	0.03	0.4	.155	.78	44.1	5.0	0.42	.006	.053	.023	.321	38.0
Sapote, (see also Zapote)	*Calocarpum mammosum* (L.) Pierre	Sapote	4	3,000	57.9	0.57	1.7	.287	1.12	44.5	32.4	0.54	.164	.002	.016	2.328	27.5
Sunzapote	*Licania platypus* (Hemsl.) Fritsch	.....	32	.....	67.4	0.49	0.9	.230	.96	10.5	29.1	1.70	.273	.016	.013	1.466	11.0
Zapote	*Calocarpum mammosum* (L.) Pierre	Sapote	26	3,000	60.3	0.82	2.9	.251	.89	28.2	23.6	1.30	.269	.000	.006	1.666	11.2

Zapotillo (a)	*Calocarpum mammosum* (L.) Pierre	Sapote	14	3,200	63.8	0.13	1.2	.492	1.24	121.0	29.7	0.79	.665	.006	..046	1.890	39.5
Zapotillo (b)	*Pouteria campechiana* (HBK.) Baehni	.....	29	.....	62.9	0.68	0.9	.354	.94	15.9	31.0	0.85	.382	.021	.019	1.227	28.4
	DRY SAMPLES																
	Cereals																
Arroz	*Oryza sativa* L.	Rice	26	3,000	7.6	0.72	0.4	1.130	.53	4.5	123.8	1.20	.000	.088	.038	2.533	.....
Maicillo	*Sorghum vulgare* Pers.	Kafir corn	23	.....	9.5	3.37	1.4	1.407	1.32	12.6	259.0	5.50	.017	.466	.087	3.039	.....
Maiz blanco	*Zea Mays* L.	Maize	26	.....	7.3	4.37	1.3	1.478	1.34	5.8	305.0	2.27	.011	.426	.090	2.155	.....
Maiz negro	*Zea Mays* L.	Maize	26	3,000	7.6	4.27	1.3	1.323	1.35	7.2	308.0	2.00	.002	.372	.088	2.430	.....
	Legumes																
Frijol blanco pequeño	*Phaseolus vulgaris* L.	White bean	23	.....	10.8	1.81	3.9	3.818	3.64	105.0	455.0	7.72	.020	.327	.135	2.235	.....
Frijol negro	*Phaseolus vulgaris* L.	Black bean	3	.....	7.2	1.45	4.1	3.810	3.86	129.4	516.0	8.52	.009	.160	.147	2.435	.....
Frijol rojo	*Phaseolus vulgaris* L.	Red bean	23	.....	10.9	1.79	4.8	3.998	3.52	115.6	431.0	7.95	.022	.190	.163	2.221	.....
Frijol tinco rojo	*Phaseolus vulgaris* L.	Red bean (small)	23	.....	8.4	1.80	4.0	3.390	3.28	113.4	352.0	6.68	.016	.237	.148	2.342	.....
Garbanzo	*Cicer arietinum* L.	Chick pea	23	.....	8.8	5.88	2.8	3.080	2.46	151.4	291.1	7.88	.033	.217	.185	1.774	.....
Maní	*Arachis hypogaea* L.	Peanut with skin.	23	.....	4.6	44.30	2.1	4.830	2.50	44.7	465.0	2.41	.013	.591	.105	23.650	.....
		Peanut without skin	23	.....	4.5	45.80	1.5	4.820	2.46	24.5	478.0	1.64	.015	.539	.104	25.350	.....
	Berries																
Café malacara	*Coffea arabica* L.	Malacara coffee	33	1,500-1,800	8.7	8.17	21.3	2.290	3.64	87.9	133.0	7.34	.017	.216	.044	1.134	.....
Chile picante (a)	*Capsicum annuum* var. *acuminatum* Fingh.	Red pepper	23	.....	5.7	9.62	26.0	2.920	8.98	223.6	340.0	11.98	2.920	.133	2.830	4.075	5.6
Chile picante (b)	*Capsicum annuum* var. *longum* (DC.) Sendt.	Hot pepper	23	.....	5.2	11.33	23.5	2.390	7.61	104.6	237.5	8.87	2.995	.122	2.565	12.310	8.3
	Gourds, seeds of																
Ayote, semilla de	*Cucurbita Pepo* L.	Pumpkin seed	5	3,000	4.2	47.65	1.5	6.099	5.22	35.8	1334.0	12.01	.056	.195	.139	1.992	.....
Pipián, semilla de	*Cucurbita Pepo* L.	Pumpkin seed	13	.....	2.3	49.10	1.5	5.630	4.89	29.5	1246.0	13.46	.036	.177	.112	2.228	.....

TABLE 2 (*Concluded*)

Composition of Food Samples From El Salvador

Name of food sampled			Place of origin and altitude[1]		Constituents measured and yields per 100 gm.												
Spanish	Scientific	English			Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid total
			Code No.	*ft.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
	Miscellaneous																
Gengibre	*Zingiber officinale* Roscoe	Ginger	26	3,000	82.1	0.80	2.1	.420	1.59	47.6	87.3	2.84	.026	.016	.043	.780	3.7
Jugo de caña	*Saccharum officinarum* L.	Sugar cane juice	20	1,700	81.1	0.03	....[2]	.052	.42	6.5	10.1	2.03	.004	.019	.017	.097	4.1
Madre de cacao	*Gliricidia sepium* (Jacq.) Walp.	Whole seed	....	.....	3.8	12.32	11.3	7.230	4.13	213.6	844.0	7.55	.030	1.915	.330	1.178	.....
Morro	*Crescentia alata* HBK.	Fruit pulp	....	.....	73.2	0.87	1.9	.235	2.00	12.5	49.5	0.62	.002	.181	.046	1.148	.....
Morro	*Crescentia alata* HBK.	Fruit pulp extract	....	.....	94.0	0.02	....[2]	.015	.55	7.9	7.9	0.24	.001	.045	.014	.284	2.2
Morro	*Crescentia alata* HBK.	Whole seeds	....	.....	4.7	34.00	11.6	5.270	3.65	57.8	896.0	7.67	.019	.753	.152	.483	.....
Morro	*Crescentia alata* HBK.	Seed kernel	24	.....	2.1	45.20	2.4	6.160	4.08	43.7	1047.0	10.73	.030	.710	.108	1.200	.....

[1] The place of origin is shown by a code number identified (Table 1). [2] Too low to determine.

de Agronomía. Roots for the prepared samples were scraped and the flesh chopped or diced.

HERBAGE VEGETABLES:

Acapate. This plant is native, or in many places spontaneous, from Mexico to Panama, and in the West Indies and South America. When fresh it has a rather disagreeable odor, but it imparts enticing flavor when cooked with other foods. It is rather commonly used in some parts of Central America as a condiment in soups and stews and other similar dishes. The sample consisted of new basal leaves from plants purchased in a San Salvador market. These were washed, wiped dry, and chopped.

Agría (I, *Rosa de Jamaica*). The sample consisted of the accrescent calyces from about 500 flowers taken from plants grown for fiber at the Centro Nacional de Agronomía.

Apio (II, *Apio*). The sample of celery, purchased in a San Salvador market, consisted of three rather large bunches of mature, green stalks of not very good quality. The stalks were separated, trimmed of leaves and poor spots, and after being washed and dried were diced for subsampling.

Berro (II, *Berro*). The sample of watercress comprised the top leaves from about 100 plants purchased in the Santa Tecla market.

Chipilín (II, *Chipilín*). Sample (a) of *chipilín* was obtained where the plants grew and consisted of plants with flowers and young fruits. Leaves and flowers were mixed for the prepared sample. Sample (b) was purchased in a San Salvador market and was made up of about 150 young plants without flowers. Tender leaves and growing points were used for the prepared sample. Sample (c) was purchased in the Santa Tecla market and was made up of about 250 very fresh, young tender stems, with some inflorescences showing but with no flowers. For the subsample, the tender upper parts of the stems and leaves were chopped.

Chufle. This plant is native in Central America usually in moist localities. The immature inflorescences form the edible portion. These may be used as a vegetable, folded into egg batter, or made into a stuffing for peppers. Apparently they are not commonly used in the dietary. The sample was purchased in the Santa Tecla market. For subsampling the inflorescences were cleaned and chopped.

Espinaca (I, *Espinaca*). Both samples of New Zealand ice plant were obtained where the plants grew. All plants were mature. The tender stems and leaves from Sample (a) were chopped and mixed for the prepared sample. The plants of Sample (b) were washed and dried superficially and the tender terminal stems and leaves used.

Izote, cogollo de (II, *Izote, flor de*). This plant is a common and relatively cheap food. It may be used as a boiled vegetable, or chopped and cooked with egg. Sample (a) was purchased in the Santa Tecla market and consisted of the tender inner part of new growth at the base of new leaves. The material was pale-green-to-white or pinkish. Sample (b) was also purchased in the Santa Tecla market, but at a much later date, and consisted of 39 tender, growing points with white, moist, bitter flesh. These were peeled and the tender parts diced and mixed for subsampling.

Izote, flor de (H. *Izote, flor de*). Two lots of yucca flowers were purchased in the Santa Tecla market on widely separated dates. The first consisted of three and the second of five inflorescences. Sample (a) was from the first lot purchased and Samples (b) and (c) from the second. The majority of the flowers on all inflorescences was open. Samples (a) and (b) comprised the perianth part of the flower only, while Sample (c) consisted of the ovaries of the flowers used to obtain Sample (b).

Lechuga (H. *Lechuga*). The two samples of romaine lettuce were purchased in the market, Sample (a) at Santa Tecla and Sample (b) at San Salvador. Sample (a) consisted of the leaves from about 70 young plants. These were chopped and mixed for subsampling. Six mature plants made up Sample (b). These were washed, superficially dried, and chopped for subsampling.

Loroco. The *loroco* is native of Central America and is sometimes used for food, although it seems to be cultivated only rarely. The flowers may be cooked as a green, folded into egg batter, or added to a kind of tortilla. A large number of greenish-white flowers, mostly in the bud stage, made up the sample, purchased from the woman who collected them. For subsampling, the flowers, including open flowers, buds, calyces, and tender pedicels, were chopped and mixed.

Madre de cacao. This tree, a legume, is native, or has been naturalized, from Mexico through Central America and into northern South America. It was undoubtedly in cultivation long before the discovery of Central America by the Spaniards and is now seen planted in much of the area. It has long been used by the Indians as shade for cacao and is now used extensively as shade in the coffee plantations. The wood is used often in construction, especially as posts in houses, since it is resistant to decay and termites. The seeds and bark are said to be poisonous to rodents and when pulverized and mixed with a food are used to exterminate these pests. The flowers are often used as food by people in the country, but because of their great abundance when the trees are in flower they are seldom seen in the market. They are used as a green or put in soups. Whole flowers and buds, taken from the trees, were used in the sample.

Mora (H. *Macuy*). Both samples of this weedy herb were purchased in the Santa Tecla market but at widely separated times. Only the tender new growth was used in the subsampling of Sample (a). Sample (b) consisted of 100 immature stems at the flowering stage. For subsampling the leaves only were chopped.

Motate; pollita. This plant is native of Mexico, Central America, the West Indies, and northern South America. It is abundant throughout Central America but seems to be used as food most commonly in El Salvador. The outer part is peeled off and the tender base of new growths is eaten either cooked as a vegetable, in stews and soups, or folded into egg batter, or raw in salads. Samples (a) and (b) were purchased at different times in the Santa Tecla market. Sample (a) comprised 59 succulent new growths from leaf bases. These were white and fairly moist. For subsampling they were trimmed, and quarterings chopped together. Sample (b) consisted of seven bleached centers of the plant. For subsampling the outer parts were peeled off and the tender inner parts were chopped

and mixed. Specimens of Samples (a) and (b) were bases of new growth that was to flower. The sample of *pollita*, from a San Salvador market, consisted of 24 tender new growths from offsets that were primarily leaf bases. These were white, fairly tender, but had some fiber. For subsampling the outer leaf bases were removed, the hard tops cut off, and after trimming they were diced and mixed.

Pacaya (II, *Pacaya*). The inflorescences of palms, either native or introduced, are used occasionally as food in El Salvador, but the relatively high cost makes their use uncommon. The sample of 24 inflorescences, purchased in the Santa Tecla market, probably represents material from 24 trees.

Palmito de coyol. The tender parts of palm cabbage or leaf base may be eaten raw but are usually cooked—either boiled or roasted. They may also be pickled, either raw or after boiling. The sample comprised four tender cabbages taken from wild plants. These were purchased in the Santa Tecla market. For subsampling the tender leaf bases and growing points of the stems were diced and mixed.

Perejil. Parsley is presumed to be a native of the Mediterranean area but is adventive now in many parts of the world. The first recorded uses were as a medicinal. It is not common in markets of Central America although it is easily grown. It may be used in salads, in soups, and in egg dishes. The sample was purchased in a San Salvador market. For subsampling the leaves were washed and dried superficially, then chopped and mixed.

Pito; quilite (II, *Pito*). The sample of *pito* was collected from the trees and comprised about 100 inflorescences. The calyces were green and the corollas red. They were rather hard and dry. The sample for analysis included buds and flowers. The sample of *quilite* was purchased in the Santa Tecla market and consisted of about 75 growing shoots with young leaves. These were washed and dried; the tender shoots and leaves were then chopped and mixed.

Pollita. See *Motate*.

Repollo (I, *Repollo*). The two samples of cabbage were taken from the field. Sample (a) grew on the Volcán de San Salvador and Sample (b) in an experimental plot at the Centro Nacional de Agronomía. Sample (a) consisted of eight mature, pale-green-to-white heads; Sample (b) of four small mature heads. For subsampling sections from the several heads were chopped and mixed.

Yuca, hojas de (I, *Yuca blanca, hojas de*). The sample was collected from an experimental plot at the Centro Nacional de Agronomía and consisted of growing points and new leaves. The harder petioles were removed before chopping and mixing for subsampling.

FRUIT VEGETABLES:

Aguacate (I, *Aguacate;* II, *Aguacatillo*). The five samples of avocados were purchased at different times in the Santa Tecla market. Sample (a) consisted of 10 small fruits of the West Indian race, with thin black skins. The flesh was deep orange-yellow, fibrous, and the flavor was not very good. Sample (b) was made up of nine small fruits with large seeds and thin

purple skins. These probably had some admixture from the Mexican race. Sample (c) consisted of 12 small ripe fruits and Sample (d) of six ripe, black-skinned fruits, probably from a seedling tree. The 12 fruits of Sample (e) were of the Mexican race. They were thin-skinned and ripe. For subsampling of each sample the flesh of the fruits was scraped out of the shells and mixed.

Berenjena (I, *Berenjena*). Samples (a) and (b) of egg-plant were obtained on the Volcán de San Salvador where they grew. Sample (a) consisted of 24 small, mature fruits and Sample (b) of 10 fruits with white flesh and light purple skins. There were five fruits in Sample (c). These were grown by hydroponics at the Centro Nacional de Agronomía, using a solution containing amounts of salts in parts per million as follows: potassium nitrate 639, calcium sulphate 1,388, magnesium sulphate 417, potassium phosphate (monobasic) 139, ammonium sulphate 139, ferric ammonium citrate 4.4, and boric acid 3.3. For subsampling the fruits were peeled and the seeds and flesh chopped and mixed.

Chilacayote. This large fruit may be eaten cooked but usually a sort of candy is made of it. The sample comprised one fruit, all that was available, purchased in the Santa Tecla market. The fruit was cut lengthwise and portions of the flesh from one-half used in the prepared sample.

Chile ciruela. This hot pepper is used to season food. The sample was obtained in a San Salvador market and consisted of 75 fruits of 15 to 20 gm. each. About two-thirds of the fruits were green and the remainder red. The fruits were washed, dried, trimmed, and the seeds removed. The flesh with skin was diced and mixed.

Chile dulce; chile verde (I, *Chile dulce*). The fruits of one sample of sweet pepper, *chile dulce*, were taken from the growing plants and consisted of 14 green fruits, immature but ready to eat. The second sample, *chile verde*, was purchased in the San Salvador market and comprised 20 green fruits. These were washed and dried before subsampling. The flesh and skins were included in the samples for analysis.

Chile pepino; chile picante (a). The fruits of this chile are small, about 15 to 30 mm. long and eight to 15 mm. broad, ovoid in shape, and red, with the calyx seated on the base and not embracing it. They are exceedingly acrid. The plant is a cultigen and probably originated around Cobán in Guatemala, where it is commonly grown. The sample, known locally as *chile pepino*, was purchased in the Santa Tecla market and was made up of about 500 small, mature, red fruits. These were washed, the calyces removed, and whole fruits taken for the subsamples. The sample called *chile picante* was purchased in a San Salvador market and included 26 small, ripe, red fruits. The seeds were removed before subsampling.

Chile picante (a). See *Chile pepino*.

Chile picante (b) (II, *Chile guaque*). This sample came from plants in an experimental plot at the Centro Nacional de Agronomía and comprised 23 orange-yellow or yellow, ripe fruits. These were washed and dried and the stems, bases, and seeds removed. The flesh with skin was chopped for subsampling.

Chile verde. See *Chile dulce*.

Cuchamper. This plant is native in Guatemala and El Salvador and possibly elsewhere in Central America. There are several species of *Vincetoxicum* in Central America, the young and tender fruits of which may be cooked and eaten. Fruits of *Vincetoxicum Salvinii* are cooked, used in stews, or made into a candy. When very young and tender the fruit with seeds may be eaten raw. Both samples consisted of immature, ready-to-eat fruits having pale-green flesh. Those of Sample (a) were obtained where they grew. Sample (b) was purchased in the Santa Tecla market. Fruits of Sample (a) were peeled and the flesh and seeds diced for subsampling. Skins and seeds of fruits of Sample (b) were removed before subsampling.

Guisayote; guisquil; huisquil (I, *Guisquil*). Three samples of chayote were analyzed. The sample designated as *guisayote* was purchased in the Santa Tecla market and consisted of 18 small spineless fruits having nearly white skins and flesh. The sample of *guisquil* represented the common variety and comprised 12 mature fruits taken from the plants. The sample of *huisquil* was purchased in a San Salvador market and consisted of 20 spineless fruits of about 100 gm. with white skins and pulp. This is the best variety of chayote and is abundant in markets of El Salvador. All subsamples were made from pulp and seeds.

Guisquill. See *Guisayote.*

Huisquil. See *Guisayote.*

Pepino (I, *Pepino*). Six green cucumbers at a stage for use in salads made up the sample which was purchased in a San Salvador market. These were peeled and the flesh diced and mixed for subsampling.

Pipián (I, *Ayote*). Samples (a), (b), and (d) of summer squash were purchased in a San Salvador market and Sample (c) in the Santa Tecla market. Sample (a) comprised 20 mature fruits of about 150 gm., having white flesh and very thin, pale-green skins with dark-green stripes. Sample (b) was made up of 20 small, tender fruits having pale-green or cream flesh and green skins with longitudinal black stripes. The fruits of Sample (c) were immature, with light-green or white skins and dark-green stripes. The six fruits of Sample (d) were of the common form used when very immature. They were rather large, but were tender and good. Subsamples of the three samples were made with whole fruits. Fruits of Samples (c) and (d) were washed.

Tomate; tomate chapadón; tomate de jugo; tomate Jocote (I, *Tomate*). The four samples of tomato differed considerably in appearance. The sample of *tomate,* purchased in the Santa Tecla market, consisted of 15 small, ripe, red juicy fruits. The sample of *tomate chapadón,* purchased in a San Salvador market, comprised 30 small pear-shaped ripe fruits of about 50 gm. These were washed and whole fruits used in the subsamples. The sample of *tomate de jugo* consisted of 45 small, ripe fruits of a peculiar variation with the appearance of a back cross to the cherry tomato. These were from plants in an experimental plot at the Centro Nacional de Agronomía. For subsampling they were washed and whole fruits taken. The sample of *tomate Jocote* was purchased in a San Salvador market and consisted of small red berries of about 25 gm. This was a common type of tomato and was plentiful in the market.

Tomatillo (I, *Miltomate*). The cherry tomatoes were purchased in the San Salvador market. There were about 2,000 ripe, red berries. These were washed and dried superficially, the stems removed, and subsamples made using the whole berries.

CEREALS:

Elote; maíz de apante (I, *Jilote*). The six samples of green corn were collected in different months from December through July in the interval February, 1947 through June, 1949. Samples (a), (b), and (c) of *elote* and the sample of *maíz de apante* were purchased in the Santa Tecla market. Sample (d) of *elote* and the sample of *elote de apante* came from the market in San Salvador. The number of ears per sample varied from 10 to 18. All kernels were white. Those of Sample (a) of *elote* and of *elote de apante* were between the milk and dough stage. The kernels of the others were in the soft dough stage. The sample of *elote de apante* is an example of corn grown in the dry season on wet land. For subsampling of each sample the kernels were cut from the cob and mixed.

Masa de tortillas. This one sample of dough from which tortillas are prepared was purchased in the Santa Tecla market, where tortillas were being made. The dough as purchased, i.e. uncooked, was used in the subsample.

LEGUMES:

Cujín; guajiniquil. This tree is assumed to be native in El Salvador. The Ingas are used extensively for shade in coffee plantations and it is possible that this species was introduced. Both samples were purchased in the Santa Tecla market, one in February and the other in June. The sample of *guajiniquil* comprised about 100 pods at a stage ready to use, and the sample *cujín*, 19 pods. The white pulp or aril surrounding the seeds was used for the prepared sample. The seeds were discarded.

Ejote (a) (I, *Frijol de vaca*). Seventy-two long, slender, green immature pods of the cowpea, purchased in the Santa Tecla market, made up the sample. These pods are used like snapbeans. The pods were washed, dried, trimmed, and chopped.

Ejote (b)-(d) and *ejote de seda* (I, *Habichuela;* II, *Ejote*). Of the snapbeans Sample (b) and the sample of *ejote de seda* were purchased in the Santa Tecla market, Samples (c) and (d) in the San Salvador market. Sample (b) consisted of 500 green pods at the ready-to-eat stage, Sample (c) of 300 fresh, tender green pods, and Sample (d) of small, rather tender, pale-green pods with very immature seeds. Beans similar to those of Sample (c) are used in soups, or cooked and added to scrambled eggs, or eaten as a cooked vegetable. The sample of *ejote de seda* was made up of about 200 pods of the common bean. These were fresh but somewhat more mature than snapbeans generally used. For subsampling the pods of all samples were trimmed and chopped. Those of Samples (c), (d), and *ejote de seda* were washed and dried before trimming.

Frijol negro; frijol tierno (I, *Habichuela*). The two samples of fresh shelled beans were purchased in a San Salvador market, the first, *frijol negro* or common black bean, in 1946, and the second, *frijol tierno*, in 1949. The second sample consisted of 300 plants with pods attached. For subsampling the shelled beans were mixed.

Frijol tierno. See *Frijol negro.*

Guajiniquil. See *Cujín.*

Paterno (I, *Paterna*). *Paterno* or *paterna* is found from southern Mexico to Costa Rica and doubtless is native in at least part of the area. Because of its use as shade for coffee trees it is usually found as a cultivated plant. It may have been planted more than other Ingas, since the fruits are quite commonly used as food. The sweet white aril surrounding the seeds is eaten raw and the seeds may be cooked as a vegetable, or cooked, blanched, and salted for use as a dessert or in salad. Twelve large pods of this legume were purchased in Santa Tecla market. Only the aril, or sweet juicy covering of the seed, was used in Sample (a). Sample (b) consisted of the seeds from which the aril had been removed. These were diced for subsampling.

Pepeto. This tree is native from the south of Mexico to Panama. In El Salvador it is used for shade for coffee trees, but it is not known whether the seeds for the trees were brought in or were secured from native material. The sample comprised about 200 legumes purchased in the Santa Tecla market and came from nearby trees. The sample for analysis consisted of the sweet aril only and the amount required was obtained at considerable expenditure of time.

FRUITS:

1. CITRUS FRUITS:

Mandarina (I, *Mandarina*). The sample of tangerines consisted of 17 fruits purchased in the Santa Tecla market. The peel was beginning to turn yellow and the flesh was deep-orange in color, sweet, and juicy. For subsampling the fruits were peeled, the seeds removed, and the flesh and pulp mixed.

Naranja (III, *Naranja*). Seventeen ripe oranges, purchased in the Santa Tecla market, made up the sample. The flesh of these fruits was a deep-orange color but was rather sour as is usual in this common variety of orange.

Naranja agria. The sour orange is a native of southeastern Asia. It was introduced into America in the 16th century and has become spontaneous in several places. It is used extensively as a stock plant for grafting the sweet orange. In Central America sour oranges are not eaten to any extent as a fruit out of hand. The juice may be used in place of lemon juice or vinegar to flavor meats and soups, and in making candies and conserves. An oil expressed from the peel is used to flavor a liqueur. The sample comprised 14 essentially ripe fruits taken from trees in Santa Tecla. Twelve of the fruits had green skins and two had orange skins. The flesh was very acid. For subsampling the superficial layer of skin and the seeds were discarded and the pulp and peel were mixed.

Naranja lima (I, *Lima limón*). Fourteen large ripe fruits, purchased from a grower in Santa Tecla, made up the sample. Only the juice was used in the subsample. It was pale-yellow-green in color and rather bland.

Toronja (I, *Toronja*). The sample consisted of six fair-sized, ripe grapefruit purchased in the Santa Tecla market. The fruits were rather acid but good. The pulp and juice were used in the sample for analysis.

2. BANANAS:

Banano; guineo (I, *Banano*). The five samples of bananas were all purchased in the Santa Tecla market at different times over a period of three years and within the months from January through September. The sample of *banano de seda* comprised 15 fruits of optimum ripeness with pale, cream-yellow flesh, fairly moist, and of good flavor. Eight good-sized fruits, of optimum ripeness, made up the sample of *banano patriota*. These were grown in the highlands. The sample of *guineo colorado* comprised 12 mature fruits. This is a red-skinned variety. The sample *guineo manzana* represents the apple banana. These fruits were small and the pulp was drier than that of the Gros Michel banana, but with a better flavor. Twelve ripe fruits from four hands made up the sample of *guineo morado*. The skin of these fruits was red and the flesh very pale-orange, firm, and rather dry. All subsamples were taken from the mashed mixed pulp of several fruits.

3. PLANTAINS:

Guineo; majoncho (I, *Plátano*). Like the bananas, the samples of plantains were purchased in different months from January through September during three years. The sample designated *guineo criollo*, purchased in the Santa Tecla market, consisted of 14 fruits from five hands of the common, small angled plantain. They were very green and immature, with hard flesh. For subsampling they were peeled and the flesh was diced. Fifteen ripe, normal-sized fruits, purchased in the Santa Tecla market, made up the sample of *guineo morado*. The flesh was deep-yellow, fairly moist, and soft. The sample of *majoncho* (a), purchased in Santa Tecla, consisted of 26 mature fruits of a small-fruited plantain. Sixteen ripe fruits from eight hands comprised the sample of *majoncho* (b). They were purchased in San Salvador and had pale-yellow, fairly moist flesh. Subsamples of the last three samples were taken from the mashed, mixed flesh of several fruits.

4. OTHER FRUITS:

Ama uva (III, *Ama uva*). The sample, purchased in the Santa Tecla market, comprised about 20 racemes of ripe fruits, green-purple-to-purple in color, the individual grapes weighing about 0.5 gm. each. Whole berries were used in the subsamples for analysis.

Anona blanca. This species of Annona is now native from southwest Mexico to El Salvador and in many places is cultivated for its fruits, said to be the finest of the genus. The sample consisted of 18 mature fruits taken from the trees. They had white or cream flesh and excellent flavor. The flesh surrounding the seed was used for the subsample.

Anona rosada (III, *Anona*). The sample, purchased in the San Salvador market, consisted of five large, ripe, smooth, pale-pink, heart-shaped fruits with pale-cream, moist flesh containing some stone cells. Flesh only was used in the subsample.

Caimito (III, *Caimito*). Twenty small, green fruits, purchased in the Santa Tecla market, made up the sample. Flesh only was used in the subsample.

Capulín. The Jamaica cherry is native from Mexico through Central America to northern South America, and in the West Indies. The tree is

rather common in Central America and although the fruit has not been seen for sale in any market it is much sought after by small boys. The fruits are small, red, sweet, and have many small seeds. The sample consisted of about 200 fruits taken from a tree at the Centro Nacional de Agronomía in Santa Tecla.

Capulín Montés. This fruit is native of Guatemala, El Salvador, Honduras, and possibly elsewhere in Central America. The tree is not commonly cultivated and the fruits are not often seen in markets. The fruits are greenish in color and sweet. They are eaten as a fruit out of hand and possibly in other ways. The sample, purchased in the Santa Tecla market, consisted of about 500 ripe fruits of about 2.5 gm. each. They were washed and dried superficially and whole fruits were then selected at random for the subsample.

Chucte; chupte. This fruit is native from Mexico to Panama and is cultivated very commonly over much of the area and especially in the state of Vera Cruz in Mexico. In cities of eastern Mexico the tree is commonly found in dooryards. In fields that have been cleared about Cobán in Guatemala these trees have been left because of their economic value. The sample of *chucte*, purchased in the Santa Tecla market, consisted of six rather large, pear-shaped fruits with thick but pliant skins and very large seeds. The sparse flesh was pale-green to light-brown in color. The sample of *chupte*, purchased in a San Salvador market, comprised six ripe fruits with fairly moist, greenish or brown-green flesh. For subsampling the flesh was spooned out of the shell and mixed.

Ciruela corona (III, *Jocote*). These trees are very common around San Salvador, grown either for their fruit or as live fence posts. The fruits are small with red skins, yellow pulp, and a very large seed. They are very common in the market. The sample was obtained in the San Salvador market and the subsample included pulp and skin.

Coco (I, *Coco*). The two samples of coconut were purchased in the Santa Tecla market but at different times. Sample (a) consisted of five fruits that were not quite ripe. The flesh was tender. Sample (b) comprised three immature fruits with tender, soft flesh of very good flavor. For subsampling, portions of flesh from the several fruits were mixed.

Coco, leche de. The sample of coconut milk came from the three coconuts comprising Sample (b) of *coco*. It was clear and free of acid taste.

Durazno (III, *Durazno*). Sample (a) of peaches consisted of 32 small, mature fruits purchased in a San Salvador market. The pulp was pale yellow. Both pulp and skin were included in the subsample. The 18 small green fruits of Sample (b) were of the clingstone variety. These were purchased in the Santa Tecla market. For the subsample the flesh was diced and mixed.

Granadilla (III, *Granadilla*). Twenty-six mature fruits, obtained in the Santa Tecla market, made up the sample of sweet granadilla. The seeds and the watery pulp were used in the subsample.

Granadilla de fresco. The giant granadilla is cultivated throughout tropical America and undoubtedly is native in some areas. One or two are seen occasionally in markets. The pulp is used to make a refreshing drink and the rind is preserved as a sweet. The two samples of this fruit

were purchased in the Santa Tecla market. The four fruits of the sample of *granadilla de fresco* had pale-green, moist flesh. The flesh only was used in the subsample. The sample of *granadilla para refrescos* consisted of five ripe fruits, and the seeds and aril from these were used in the subsample.

Guanábana. The soursop is undoubtedly native of tropical America and possibly over much of the area. The fruit is a large and good one and is much appreciated in Central America. The price often seems unreasonably high, which may be due to the fact that the trees are shy bearers. Two fully ripe fruits from the Santa Tecla market made up the sample. The flesh, free of seeds, was used in the subsample.

Guayaba perulera (III, *Guayaba*). Thirty-five mature guavas purchased in the San Salvador market made up the sample. These had greenish-to-greenish-yellow skins and pale-cream-colored pulp. The whole fruits were mixed for subsampling.

Guinda. The otaheite gooseberry, native of India and the East Indies, is cultivated infrequently in Central America and probably is used sparingly. The sample, obtained in a San Salvador market, consisted of small. pale-green fruits. The skins and pulp were the parts used.

Huiscoyol. This variety of palm is a native of El Salvador and is common in some places but is not reported as having been seen elsewhere. The pulp and seeds are eaten. The pulp is rather sparse and acid in flavor; the seeds are hard and difficult to crack. The sample comprised eight racemes of mature fruits with about 70 fruits each. These were obtained in the Santa Tecla market and came from wild trees.

Icaco (I, *Icaco*). The sample of *icaco* or cocoa-plum, obtained in a market in San Salvador, consisted of 70 ripe fruits with pink skins and white, moist flesh. The sample of *icaco morado,* from the Santa Tecla market, comprised about 50 good-sized fruits with dark-purple skins and rather dry, white flesh. For subsampling the fruits of each sample were washed and the flesh and skin cut away from the seed and mixed.

Mamey (III, *Mamey*). The four samples of mamey were very similar. Sample (a) consisted of five large mature fruits with firm, yellow flesh; Sample (b) of four mature fruits with deep-apricot-yellow flesh; Sample (c) of four fair-sized ripe fruits with firm, fairly moist, apricot-yellow flesh; and Sample (d) of four ripe fruits with firm, apricot-colored flesh. Samples (a), (b), and (d) were purchased in the Santa Tecla market, and Sample (c) in San Salvador. Flesh only was used in all subsamples.

Mamón. The genip or Spanish lime is native of South America and possibly of Cuba. It is not uncommon in Central America. The fruits are about one inch in diameter with a thin, tough skin and large seed. The pale-flesh-colored and somewhat acid pulp is rather sparse but of good flavor. The seed is sometimes roasted and eaten. The sample, from the Santa Tecla market, consisted of about 150 ripe fruits. Flesh only was used in the subsample.

Mango (I, *Mango*). The samples of *mango* and of *mango corriente* were purchased in the Santa Tecla market; that of *mango verde* in San Salvador. The sample of *mango* consisted of 15 tree-ripe fruits with moist, apricot-yellow flesh; that of *mango corriente* of 11 ripe fruits with orange-red skins and apricot flesh; and of *mango verde* of 11 green fruits. Flesh only

was used for the subsamples of the first two samples. The skin was included with the flesh in the subsample of *mango verde*.

Marañón. The cashew tree is native of Central and South America, where it is abundant both as a wild and a cultivated tree. The main supply of nuts comes from South America. In Central America the tree is prized as a source of "fruit." The cashew apple or "fruit" is the enlarged fleshy pedicel of the real fruit or nut. Twenty ripe "fruits" with red and yellow skins and pale-yellow flesh made up Sample (a). For subsampling these were peeled and sections taken. Eleven ripe "fruits," some red and some yellow, made up Sample (b). These were washed and skins and pulp diced for subsampling. Sample (a) was obtained in the market in Santa Tecla; Sample (b) in San Salvador.

Marañón japonés. The large-fruited rose apple is native of Malaya and occasionally is found planted in Central America for its fruits or as an ornamental. The thin skin is rose-colored or white, and the flesh rather dry and pithy, with one large, soft seed. Samples (a) and (c) were from the Santa Tecla market and Sample (b) from San Salvador. Sample (a) comprised 11 ripe fruits, Sample (b) 18 small fruits, and Sample (c) 12 ripe fruits. All fruits had red skins and white flesh. The skin and pulp were used in the subsamples. Fruits of Samples (b) and (c) were washed.

Matasano. The white sapote is native from Mexico to Honduras and possibly as far south as Costa Rica and undoubtedly has been planted as a dooryard tree in many places. There is much variation in the quality of the fruit, from fairly good to very poor. When completely ripe it is eaten out of hand, and in considerable quantity is said to act as a mild sedative. The sample, from the Santa Tecla market, comprised eight large ripe fruits with very sweet, pale-orange-yellow, moist flesh. For subsampling the flesh only was diced and mixed.

Melón. The melons are native, perhaps, of southern Asia or of Africa. Melons are not common in Central America. They are cultivated at low elevations and, in the dry season, along the bars of rivers. Those found in markets are expensive. The sample was obtained near where it grew, on the bank of the Río Lempa in the vicinity of the Cuscatlán Bridge. It comprised four fairly large ripe fruits of the honeydew variation, with pale-greenish-yellow flesh. For subsampling longitudinal quarter-sections were peeled, the seeds removed, and the flesh diced and mixed.

Mora. This very fine fruit is native to the highlands of South America and probably also from Guatemala to Panama. This species belongs to the raspberry group of *Rubus*, but the fruit holds the receptacle like a blackberry. In flavor it is not like either one. The large fruits become black or dark-red when ripe. Both samples were collected from the same patch on Volcán de San Salvador. Sample (a) was taken in September, in the wet season, and Sample (b) in February, in the dry season. Whole fruits were mashed for subsampling.

Nance (III, *Nance*). The two samples of this fruit were purchased at different times in the San Salvador market. Sample (a) consisted of very small mature fruits with yellow skins and soft, yellow flesh. Sample (b) was made up of about 200 large ripe fruits with yellow skins and white or pale-yellow, soft, moist flesh. The flesh, and the skin, which is very

thin, were cut away from the large seed and mixed for subsampling. The fruits of Sample (b) were washed.

Níspero (I, *Níspero*). Sample (a) of the sapodilla, obtained in the Santa Tecla market, comprised 12 mature fruits with yellow flesh, bland but of good flavor. Sample (b), from the San Salvador market, consisted of 12 ripe fruits. For subsampling the flesh, free of seeds, was used.

Papaturros. This fruit is native of Central America and northern South America. It is occasionally seen in markets of Central America and probably is used often where it grows. The fruit is borne in large racemes and has a slightly acid but fair flavor. The flesh is white or pink and sticks to the single black seed. The sample, obtained in the Santa Tecla market, consisted of a large number of racemes with about 5,000 individual ripe fruits each. The fruits were washed and several hundred used for each sample.

Papaya (III, *Papaya*). The sample of papaya was purchased in the Santa Tecla market and comprised two rather large ripe fruits, with moist flesh of good color and fine flavor. The sample of *papaya verde* was taken from trees at the Centro Nacional de Agronomía in Santa Tecla and comprised four green fruits of 550 to 950 gm. The flesh was firm, white, and juicy. These fruits were at the stage when they would be used for pies. Flesh only was used in subsampling both samples.

Pepino (II, *Pepino*). The sample of melon pear was secured on the Volcán de San Salvador where it grew, and consisted of 20 fruits of 40 to 60 gm. each. The flesh was pale-green-to-whitish, heavy and watery, but firm. For subsampling the fruits were peeled and quartered.

Piña (I, *Piña*). The sample of *piña* was obtained from the grower and was made up of five vine-ripened fruits with very moist, yellowish flesh. The sample of *piña azucarón* consisted of three ripe fruits with quite yellow flesh. This variety is much prized, as the fruits are very juicy and sweet. The sample of *piña de Castilla* consisted of four ripe fruits with yellow, quite moist flesh. The latter two samples came from the Santa Tecla market. For subsampling longitudinal wedges of the fruits were peeled, cored, and diced.

Pinuela. This plant is native from Mexico and the West Indies to northern South America. The young leaves or growing points, the flowers, and the fruits are variously used for food. The fruit may be eaten raw but is generally cooked or made into a preserve with crude sugar. Both samples were purchased in the Santa Tecla market but at different times. Sample (a) consisted of 35 ripe fruits and Sample (b) of 150 mature fruits with moist, white, acid flesh. For subsampling the fruits were peeled, the seeds removed, and the flesh diced.

Sapote; Zapote (I, *Zapote*). Both samples were purchased in the Santa Tecla market at different times. The sample of *sapote* comprised five normal-sized fruits with orange-red flesh and russet skins. The other sample, *zapote*, consisted of eight mature fruits of about 300 gm. each. The pulp was brown or reddish. For subsampling the single black seed was taken out, and flesh removed from the shell and mixed.

Sunzapote. This large and rather handsome tree is native from Mexico through Central America to Colombia and is cultivated to some extent for its fruit, although it is not greatly appreciated in Central America. The flesh of the mature fruit is rather dry, with color and odor similar to that of pumpkin pie. The sample, obtained in the San Salvador market, consisted of eight fruits of about 650 gm. each. The flesh only was used.

Zapote. See *Sapote.*

Zapotillo (a). This is a curious form of the sapote seen occasionally in El Salvador. The fruits are very small and seedless; the flesh is brick-red. The sample, from the Santa Tecla market, consisted of 50 small fruits about three cm. in diameter. The flesh was spooned out of the shell and mixed for subsampling.

Zapotillo (b). This fruit is native from Mexico to Panama; also in the Florida Keys and Cuba. The skin and flesh are yellow and the flesh is rather dry. The fruit is not commonly found in the markets in Central America, perhaps because it is so dry and lacking in flavor. The sample was made up of 25 small, mature fruits from the Santa Tecla market. For subsampling the thin skin and flesh were cut from the seeds, chopped, and mixed.

DRY SAMPLES:

1. CEREALS:

Arroz (III, *Arroz*). The sample comprised dry hulled rice purchased in the market.

Maicillo. Kafir corn is cultivated quite commonly in Central America, very often interplanted with maize or in the same hill with it. It will mature on less rainfall than will maize and in certain of the drier areas it is interplanted as an "insurance crop," in case the annual rains are insufficient for maize. Its use as a food in Central America is limited, due to the stigma attached to it from its use as chicken and hog feed. When properly milled it makes a bread quite as fine as that made with corn. It is also used for tortillas. The sample came from the San Salvador market.

Maíz (I, *Jŭote*). The sample of *maíz blanco* was obtained in the Santa Tecla market, and of *maíz negro* in the San Salvador market.

2. LEGUMES:

Frijol (I, *Habichuela*). The four samples of beans were purchased in the San Salvador market. The small white beans, *frijol blanco pequeño,* are the beans most commonly cooked with pork meat. Production is not extensive and they bring a premium price. The black bean, *frijol negro,* is common in El Salvador, and the red bean, *frijol rojo,* is the second most important crop of the country. The small red bean, *frijol tineco rojo,* is used commonly and is widely planted.

Garbanzo (III, *Garbanzo*). The sample of chick-peas was purchased in a San Salvador market. In El Salvador chick-peas may be cooked as a vegetable, roasted like peanuts, or used to make a very delectable soup. It is said that they may also be used as a substitute for coffee.

Maní. Peanuts undoubtedly originated in Brazil. They are quite commonly cultivated in Central America and the unroasted seeds are to be found in most markets. They are eaten raw, roasted, or cooked as a vege-

table, usually with other vegetables. The sample came from a San Salvador market.

3. BERRIES:

Café malacara (III, *Cofé*). Coffee is the most important source of income in El Salvador. The sample was purchased from the beneficio at Santa Ana and was grown on the Volcán de Santa Ana. It is one of the best of the high-grown coffees and probably is equal to any grown in Central America.

Chile picante (a) (II, *Chile*). The sample, from the market, consisted of a large number of small, dry, red fruits three to four cm. long and one cm. in diameter toward the base. They are used primarily as a condiment.

Chile picante (b) (III, *Chile guaque*). These chiles are used chiefly as a condiment and this form is the one most often used with meat as it is cooked. Subcylindric fruits 10 to 15 cm. long made up the sample, purchased in the market.

4. GOURDS:

Ayote, semilla de; pipián, semilla de (I, *Ayote;* III, *Ayote, pepita de*). Pumpkin seed kernels are eaten raw or toasted and the whole seeds may be used to make a *refresco* or non-alcoholic drink. Specimens of the two samples, obtained in the market, looked very much alike but in the market they were sold separately and under different names. Kernels only were used in subsamples for analysis.

Pipián, semilla de. See *Ayote, semilla de.*

MISCELLANEOUS:

Gengibre. Ginger is a native of southeastern Asia and is now found in the tropics and subtropics of the world, and is cultivated somewhat in the temperate zones. Green roots, and occasionally dried ones, are to be found in many markets in Central America. It is used as flavoring for other foods or the tender parts of the root occasionally may be eaten raw. It is also used as a medicinal. The sample came from the San Salvador market. The roots were about 1.5 cm. in diameter and the flesh was a sickly green-yellow. The flesh with the very thin skin was used in the sample for analysis.

Jugo de caña. The sugar cane plant has not been discovered wild but it is believed to have originated in southeastern Asia or in the East Indies. It is a rank and rapid-growing grass and is the principal source of the world's sugar. It is grown in the tropics wherever there is adequate rainfall and the temperature is right, over areas ranging from large plantations producing sugar for export, to garden patches from which enough sugar is obtained to meet the needs of single families. The sample was extracted by hydraulic pressure from cane stalks about one year old, and was strained before subsampling.

Madre de cacao. For a description of the plant see under "Herbage Vegetables." The history of the sample is not known. The whole dry seeds were ground for subsampling.

Morro. This is a native tree found along the Pacific coastal area from Mexico to Nicaragua. It is often exceedingly common in the coastal plain area, especially where drainage is poor in the wet season, and may extend

up the coastal valleys to 3,000 feet. The fruit is large with a hard shell, and dark, almost black pulp filled with a multitude of small, flat shiny seeds. When the flesh and seeds are removed from the fruit the hard shells may be used for vessels of all sorts. The seeds may be eaten, or used to make a refreshing drink, or may be fermented along with corn or rice to make an alcoholic drink. The oil pressed from the seeds is a bland, relatively stable, edible oil. A drink is also made from the soft pulp by heating with water and straining off the liquid part.

The sample of fruits came from Guatemala, but there is no reason to believe they would be different from those grown in El Salvador. The sample of pulp was prepared from three fruits. The entire contents were taken from the shell and after the seeds had been removed the pulp was cut up and mixed for subsampling. The extract was made by mixing 500 gm. of pulp, including seeds, with 1,000 gm. of water, boiling for 12 minutes, then straining through cheesecloth. The whole seeds for analysis were ground before subsampling. The history of the sample used is not known. The sample of seeds used for obtaining the kernels was purchased in a San Salvador market and probably came from the vicinity of San Vincente. The kernels were freed of hulls by hand.

RESULTS AND DISCUSSION

The amounts of the various constituents found in the 194 samples are given (Table 2). These are expressed in terms of 100 gm. of raw, edible material. The content of some nutrients in a number of samples was relatively high and in several others high enough so that the foods might make a significant contribution to the diet. For several foods there were more than one sample and some of these showed significant differences in composition. These findings are considered in the following discussion.

Fresh Foods:

Jícama. The four samples showed considerable variation in content of ascorbic acid (3.6, 21.7, 32.5, and 38.4 mg.). The first two values were from roots purchased in the market, while the last two were from roots taken directly from the ground. These latter values are moderately high.

Papa. The values for niacin (1.343, 1.053, and 1.630 mg.) indicate that this food is a good source of this nutrient. These samples also contained important amounts of ascorbic acid (30.0, 28.4, and 24.0 mg.).

Rábano. The two samples showed a significant difference in content of ascorbic acid (37.6 and 26.5 mg.).

Yuca. The ascorbic acid content of the three samples (50.6, 20.8, and 46.2 mg.) showed some variation. If properly cooked, yucca might contribute valuable amounts of ascorbic acid in the diet.

Zanahoria. The two samples of carrots showed a large difference in their values for carotene (0.575 and 4.232 mg.). The roots of both samples were mature but those of Sample (a) had white flesh.

Acapate. This plant had a high content of calcium (295.0 mg.), of iron (5.73 mg.), of carotene (3.795 mg.), and contained a considerable amount of riboflavin (0.215 mg.).

Agría. The calcium content of this food was notably high (156.4 mg.).

Berro. The one sample of watercress was high in content of iron (3.39 mg.) and contained an appreciable amount of ascorbic acid (34.6 mg.).

Chipilín. The first two samples of this food showed a high content of calcium (270.8 and 233.8 mg.), of iron (3.52 and 3.52 mg.), of carotene (9.710 and 11.878 mg.), of thiamine (0.378 and 0.357 mg.), and of riboflavin (0.409 and 0.546 mg.). While the first of these two samples contained a moderate amount of ascorbic acid (48.3 mg.), the second contained a much larger amount (149.4 mg.). The third sample contained considerable calcium (104.3 mg.), iron (2.43 mg.), thiamine (0.264 mg.), niacin (1.285 mg.), and ascorbic acid (48.6 mg.). The content of riboflavin was high (0.418 mg.), while that of carotene was almost nil (0.018 mg.). All three samples contained relatively high amounts of nitrogen (1.179, 1.202, and 0.889 gm.).

Espinaca. The two samples of New Zealand ice plant were high in content of iron (3.85 and 4.87 mg.) and of carotene (2.810 and 2.432 mg.), and contained favorable amounts of ascorbic acid (28.2 and 34.7 mg.).

Izote, cogollo de. The calcium content of each sample of this food was very high (370.0 and 313.3 mg.). The ascorbic acid content of the first sample (34.0 mg.) was twice that of the second (16.9 mg.).

Izote, flor de. The flowers of the yucca are very high in content of ascorbic acid (560.0 mg.), with the perianth containing somewhat more (400.0 mg.) than the ovary (292.5 mg.). The niacin content is also significant and shows a distribution similar to that of ascorbic acid, with 1.680 mg. and 1.541 mg. in the perianth and 1.225 mg. in the ovary.

Lechuga. The two samples of lettuce showed marked differences in carotene content (0.124 and 1.100 mg.). The plants of Sample (a) were young and light-green in color, while those of Sample (b) were dark green.

Loroco. The flowers of this plant gave a high value for niacin (2.240 mg.).

Mora. Values from the two samples of this weedy herb show it to be an important source of calcium (202.2 and 240.5 mg.), of iron (11.67 and 7.30 mg.), of thiamine (0.186 and 0.168 mg.), of riboflavin (0.316 and 0.330 mg.), and of ascorbic acid (60.8 and 50.0 mg.).

Motate; pollita. From the values for the two samples examined, this food may be considered a good source of calcium (124.2 and 158.0 mg.) and somewhat variable in content of ascorbic acid (23.2 and 34.3 mg.).

Pacaya. The flowers of this palm are remarkably rich in calcium (474.5 mg.).

Palmito de coyol. The edible part of this palm is rich in calcium (156.9 mg.).

Perejil. The one sample of parsley was high in content of calcium (258.0 mg.), of iron (2.98 mg.), of carotene (2.217 mg.), of riboflavin (0.284 mg.), and of ascorbic acid (222.5 mg.).

Pito; quilite. The flowers, *pito*, and the young shoots, *quilite*, of this leguminous plant show equally high values for thiamine (0.208 and 0.209 mg.). The shoots were also high in iron (3.24 mg.) and carotene (2.173 mg.).

Repollo. As was to be expected, the samples of cabbage contained important amounts of ascorbic acid (39.2 and 51.7 mg.), although the difference between the amounts in the two samples is marked.

Yuca, hojas de. The cassava leaves contained large amounts of several nutrients: calcium (269.3 mg.), iron (12.78 mg.), thiamine (0.259 mg.), riboflavin (0.400 mg.), niacin (3.080 mg), and ascorbic acid (420.0 mg.). The content of nitrogen (1.430 gm.) was also high compared to values for other leafy foods examined.

Aguacate. Results are given for five samples of avocado. There was considerable variation among them in content of several nutrients, the most conspicuous being in content of niacin (0.999, 1.668, 1.112, 2.220, and 1.645 mg.).

Berenjena. The three samples of eggplant were remarkably similar in composition.

Chile. Six samples of peppers covering five variations were analyzed. The ascorbic acid content of five samples was high (110.0, 87.2, 34.4, 275.0, and 115.0 mg.) while that of the sixth, *chile ciruela*, was much lower (32.4 mg.). Wide variation from sample to sample is noted in values for niacin (1.184, 0.510, 2.634, 1.116, 1.021, and 0.844 mg.) and carotene (0.007, 0.063, 1.083, 0.905, 0.099, and 0.289 mg.).

Cuchamper. The two samples of this fruit were high in content of ascorbic acid (118.1 and 171.9 mg.).

Pipián. Values for the four samples of summer squash indicate remarkable uniformity in their composition.

Tomate. Samples representing five variations of tomato were analyzed. There was considerable variation in content of iron (2.07, 0.37, 0.50, 1.96, and 0.46 mg.) and one sample, the cherry tomato, showed a much higher content of carotene (1.558 mg. versus 0.289, 0.419, 0.423, and 0.421 mg.) and of ascorbic acid (58.5 mg. versus 30.5, 29.2, 36.3, and 32.8 mg.) than the other samples.

Elote; maíz de apante. Six samples of green corn were analyzed. All contained rather large amounts of thiamine (0.191, 0.154, 0.128, 0.190, 0.173, and 0.203 mg.) and of niacin (2.535, 2.040, 2.562, 1.948, 1.791, and 2.090 mg.).

Frijol. The content of iron (2.94 and 2.63 mg.), of niacin (1.640 and 2.622 mg.), and of thiamine (0.423 and 0.280 mg.) in each sample was moderately high and one, *frijol tierno*, contained a fairly large amount of ascorbic acid (37.7 mg.). This latter sample was purchased as beans in the shell.

Paterno. In comparing values from the two samples it should be recognized that the first sample consisted of the aril only, while the second comprised seeds only.

Citrus fruits. The sample of *naranja agria* showed a content of ascorbic acid (55.2 mg.) slightly higher than usually found in oranges.

Bananas and plantains. With the exception of unimportant variations in carotene content, the various samples of these fruits showed remarkable uniformity in composition.

Anona. Of the two annonas the first, *Annona diversifolia* gave high values for thiamine (0.235 mg.), riboflavin (0.297 mg.), and niacin (2.177 mg.), while the second, *Annona reticulata*, gave relatively low values for these three constituents (0.075, 0.086, and 0.528 mg., respectively). The

ascorbic acid values for the two samples (13.6 and 41.2 mg.) differ markedly and in inverse magnitude to values for the other three constituents.

Capulín. This fruit was high in content of calcium (124.6 mg.) and of ascorbic acid (80.5 mg.).

Ciruela corona. The one sample of this fruit analyzed contained niacin and ascorbic acid in appreciable amounts (1.676 and 73.0 mg., respectively).

Granadilla. The first sample consisted of flesh only and gave no outstanding value. The second sample comprised seeds and aril and gave a relatively high value for iron (2.93 mg.) and for niacin (1.897 mg.).

Guayaba. The one sample of guava contained less ascorbic acid (43.0 mg.) than was to have been expected on the basis of results in another report, Munsell (1945).

Guinda. The one sample of this fruit gave a high value for iron (3.25 mg.).

Mango. Three samples of mangoes were analyzed. One had a considerable amount of carotene (1.872 mg.) and all were rich in ascorbic acid (91.3, 107.2, and 172.0 mg.).

Marañón. Both samples of this so-called fruit gave a high value for content of ascorbic acid (146.6 and 231.3 mg.).

Nance. One sample showed a very high content of ascorbic acid (192.0 mg.), while the second sample, made up of somewhat larger fruits than those of the first, contained a smaller amount (90.0 mg.).

Papaya. The two samples of papaya showed a significant difference in content of ascorbic acid (57.5 and 35.5 mg.).

Pepino. This fruit gave low values for all constituents except iron (1.25 mg.) and ascorbic acid (36.7 mg.).

Piña. The three samples of pineapple contained variable but rather large amounts of ascorbic acid (40.7, 43.3, and 78.6 mg.) and unimportant amounts of all other constituents.

Pinuela. The two samples contained appreciable but significantly different amounts of ascorbic acid (56.3 and 38.0 mg.).

Sapote; zapote. The two samples of sapote analyzed contained niacin in appreciable amounts (2.328 and 1.466 mg.).

Zapotillo (a). The one sample of this peculiar variation of the sapote gave a rather high value for calcium (121.0 mg.), niacin (1.890 mg.), and ascorbic acid (39.5 mg.).

DRY SAMPLES:

Arroz. The value for niacin in rice was relatively high (2.533 mg.).

Maicillo. The kafir corn sample was high in content of iron (5.50 mg.) and of niacin (3.039 mg.).

Maiz. Values for niacin (2.155 and 2.430 mg.) in the two samples of dry corn were high, but not as high as might have been expected from the results with the immature corn, *elote.* The content of iron was high (2.27 and 2.0 mg.) and the amounts corresponded to those for the immature *elote.*

Frijol. The four samples of beans gave uniformly high values for niacin (2.235, 2.435, 2.221, and 2.342 mg.), but as with corn the values are not as high as might have been expected from the values for fresh shelled

beans. The values for iron (7.72, 8.52, 7.95, and 6.68 mg.) agreed well with those found for the fresh shelled beans. All samples gave relatively high values for calcium (105.0, 129.4, 115.6, and 113.4 mg.) and thiamine (0.327, 0.160, 0.190, and 0.237 mg.).

Garbanzo. The chick-pea is a good source of calcium (151.4 mg.), iron (7.88 mg.), and thiamine (0.217 mg.), and contains a fair amount of riboflavin (0.185 mg.) and niacin (1.774 mg.).

Maní. The peanut is apparently a superior source of niacin, as the values for the two samples analyzed were very high (23.650 and 25.350 mg.). The content of thiamine was also high (0.591 and 0.539 mg.).

Chile. Two varieties of *Capsicum* are represented by the two samples analyzed. These were high in content of calcium (223.6 and 104.6 mg.), of iron (11.98 and 8.87 mg.), and of carotene (2.920 and 2.995 mg.), and gave remarkably high values for riboflavin (2.830 and 2.565 mg.) and for niacin (4.075 and 12.310 mg.)., although here, as for other foods, the niacin value is lower than the content of the fresh food would lead one to expect.

Ayote, semilla de; pipián, semilla de. The content of iron (12.01 and 13.46 mg.), of thiamine (0.195 and 0.177 mg.), and of niacin (1.992 and 2.228 mg.) in the two samples of pumpkin seeds indicates this food could be a significant source of these nutrients in the diet.

MISCELLANEOUS:

Madre de cacao. The seeds of this leguminous plant were high in content of ether-extractable material (12.32 per cent), of nitrogen (7.23 per cent), of calcium (213.6 mg.), and of iron (7.55 mg), and contained important amounts of niacin (1.178 mg.).

Morro. These seeds had a high content of ether-extractable material (34.00 per cent), of nitrogen (5.27 per cent), of iron (7.67 mg.), and of thiamine (0.753 mg.), with somewhat higher values in the kernels for ether extract (45.20 per cent), for nitrogen (6.16 per cent), and for iron (10.73 mg.).

SUMMARY

A total of 194 samples of edible plants was collected in El Salvador during the interval between November, 1946 and June, 1949. Data are presented from the analyses of these samples for content of moisture, ether extract, crude fiber, nitrogen, ash, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid.

A number of the foods examined was found to be rich in some of these nutrients. These are considered in the discussion. A few are of importance because of their remarkably high content of one or more nutrients. The leguminous plant, *chipilín*, gave very high values for calcium, iron, and carotene, and moderately high values for thiamine, riboflavin, and niacin. Its possible sedative properties might prohibit its use in large quantity, but could not discount altogether its possible value in the diet.

The yucca plant is a source of two food products of high nutritive value, 1) the young leaf base, *cogollo de izote*, which is very rich in calcium, and 2) the flowers, *flor de izote*, which have a very high content

of ascorbic acid and a moderately high content of niacin. The leaves of cassava, *hojas de yuca*, have a high content of nitrogen, calcium, iron, thiamine, and riboflavin, and a very high content of niacin and ascorbic acid. At present they are not eaten but they could be used as a green. *Loroco*, the flowers of the Fernaldia, are also rich in niacin. The weedy herb *mora* gave high values for calcium, thiamine, riboflavin, and ascorbic acid, and very high values for iron. Like *chipilín*, this food is claimed to have sedative action. The palm flowers, *pacaya*, are exceptionally rich in calcium. This food is rather expensive and could not be an important item of the diet in El Salvador. The values for parsley, *perejil*, indicate this food is a moderately good source of calcium, iron, carotene, thiamine, riboflavin, and niacin, and very rich in ascorbic acid. As it is used in El Salvador it probably makes a significant contribution of these nutrients to the diet.

A number of foods for which there were more than one sample showed considerable variation in nutritive value between samples. These are discussed.

The niacin values for samples of green corn and dry, shelled corn, of fresh shelled and dry beans, and of fresh and dry peppers, indicate there is a decrease in the content of this nutrient as these seeds and this fruit mature and become dry.

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EXPANSIBILITY AND SPECIFIC VOLUME OF STABILIZED AND UNSTABILIZED PEANUT BUTTER[1]

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Peanut butter is comprised of a mixture of finely disintegrated solid material suspended in liquid oil, liberated from the peanut by roasting and grinding. The dispersion is relatively uniform, especially when first formed, and can be maintained in such condition for some time by the addition of so-called "stabilizing" agents, generally consisting of hydrogenated fat. Since approximately one-third of the total oil originally present in the peanut kernel (*ca.* 48 per cent) is present in the liquid phase of peanut butter, dilatometry furnishes a convenient method of determining changes in volume of this product as a function of temperature. The application of dilatometric methods likewise permits the detection of phase changes produced by various methods of heating and cooling, since such changes are usually accompanied by marked changes in volume. Because of the practical value and application of such information, an investigation was made of the dilatometric properties of different types of peanut butters.

EXPERIMENTAL PROCEDURE

Samples: The peanut butters used in this investigation were "stabilized" (Samples B and C) and "unstabilized" (Sample A). A "stabilized" peanut butter as recognized by the industry is generally one in which a material has been incorporated to prevent separation of the oil under ordinary conditions of shelf-life. The stabilizer incorporated with Sample B was a commercial mixture of equal parts of hydrogenated peanut oil, unhydrogenated peanut oil, and salt; the stabilizer of Sample C was a commercial product, which is peanut oil hydrogenated to an iodine value of about five [M. P. 64.5°C.(148°F.)].

Each product was prepared from No. 1 Grade Spanish peanuts in a 250-pound capacity, batch-type peanut butter processing plant. The peanuts were roasted, blanched in a split-nut blancher, sorted on a picking table to remove material with adhering skin and deteriorated or damaged peanuts, and ground in a peanut butter mill. Conditions used in preparing the peanuts for grinding and the weight per cent of the constituents passed through the grinder are given (Table 1). Analytical data on samples taken at various stages in the processing operations are given (Table 2).

Apparatus and Method: Dilatometers used in this investigation were of the gravimetric type with mercury as the confining liquid, Bailey and Kraemer (1944). Triplicate dilatometers were filled with the stabilized peanut butters in order that the samples could be subjected to three different

[1] Report of study made under the Research and Marketing Act of 1946.

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TABLE 1

Conditions of Processing, and Ingredients to Grinder

Conditions and ingredients	Peanut butter		
	Unstabilized	Stabilized	
	A	B	C
Time of roast, min.	17	17	23
Temp. of roast, °C.	110-149	93.5-163	96-138
Av. temp. from grinder, °C.	60	63	63
Peanuts, per cent	99	96.4	97.8
Salt, per cent	1	1.2[1]	1.5
Stabilizer, per cent	0	1.2[1]	0.7
Peanut oil added, per cent	0	1.2[1]	0.0

[1] A commercial stabilizer composed of a mixture containing equal weights of peanut oil, hydrogenated peanut oil, and salt.

TABLE 2

Analysis of Peanuts and Peanut Butters

	Peanuts			Peanut butter [3]
	Raw, shelled [1]	Roasted [1]	Blanched, from picking table [1]	
Moisture content [2]	pct.	pct.	pct.	pct.
A	6.88	.....	1.65	1.48
B	6.79	1.74	1.45	1.21
C	6.04	2.03	1.75	1.76
Oil content				
As received, Col. 1				
Moisture free, Col. 2	(1) (2)	(1) (2)	(1) (2)	(1) (2)
A	44.36 47.31	....	48.47 49.29	48.40 49.12
B	44.4 47.63	46.96 47.79	48.30 49.07	48.78 49.38
C	44.8 47.7	46.99 48.0	48.42 49.3	47.29 48.1
Free fatty acids in extracted oil				
A	0.42	.....	0.59	0.62
B	0.48	0.21	0.18	0.17
C	1.14	0.21	0.18	0.12

[1] Prepared in a Henry Slicer. [2] Ground peanuts plus salt and hydrogenated peanut oil (except Sample A). [3] Forced draft oven at 130°C.(266°F.) for three hours.

heat treatments prior to making the dilation measurements. These treatments were:

(1) Heated to 80°C.(176°F.), rapidly cooled to —40°C.(—40°F.) by plunging into a bath at —40°C.
(2) Heated to 80°C., slowly cooled to —40°C. over a period of 24 hours.
(3) No heat other than that resulting from the grinding operation.

Heating to 80°C. insured the complete melting of the stabilizing material incorporated with the stabilized peanut butters. The unstabilized peanut butter received no preliminary heating. Expansibility determinations were begun at an initial temperature of —38.60°C.(—38°F.).

The absolute density of peanut butter was determined by pycnometer in order that the expansibility of each sample might be expressed on an absolute basis. This value was found to be 1.1112 gm./ml. at 26.5°C.(79°F.).

An approximation of the solubility of incorporated stabilizer in the free oil phase of peanut butter was determined by stirring for six minutes

a sample of extracted peanut butter oil and added stabilizer at 60°C. (140°F.) (the temperature generally obtained in the grinding operation during the manufacture of peanut butter). Actually, the peanut butter would not have been in the grinder as long as six minutes, but this time was required in order to insure a maximum solubility value. It was found that about eight per cent by weight of the stabilizer was dissolved by the free oil phase.

RESULTS

The expansibilities of the peanut butter samples were determined over a range of temperature from −38.6 to 70.0°C.(−38 to 158°F.) and the absolute specific volumes at various temperatures calculated. Results are given (Table 3). The specific volumes of representative samples were used to construct the curves which are reproduced (Fig. 1).

Expansibilities in the Solid and Liquid States: The temperature range in which the oil content of the peanut butter was completely in the solid state is probably lower than the lowest temperature used in these determinations, and the calculated expansion of peanut butter in the solid state is, therefore, probably high. An average value for the three unheated peanut butters was determined to be 0.00031 ml./gm./°C., in the temperature range −38.6 to −27.5°C.(−38 to −18°F.). Since there was no significant deviation from a straight line in the slope of the specific volume-temperature curve above 12°C.(54°F.), which would not be so if

TABLE 3

Specific Volume of Stabilized and Unstabilized Peanut Butter

Temp., °C.	Specific volume, ml./gm.						
	Preheated				Not preheated		
	Sample B		Sample C				
	Slowly cooled	Rapidly cooled	Slowly cooled	Rapidly cooled	A	B	C
−38.60	0.8525	0.8538	0.8533	0.8532	0.8583	0.8698	0.8646
−34.05	0.8539	0.8551	0.8546	0.8545	0.8588	0.8715	0.8667
−27.50	0.8560	0.8567	0.8567	0.8566	0.8594	0.8741	0.8697
−22.81	0.8585	0.8590	0.8592	0.8590	0.8599	0.8758	0.8720
−16.55	0.8683	0.8689	0.8689	0.8688	0.8653	0.8785	0.8757
− 9.83	0.8741	0.8741	0.8742	0.8741	0.8734	0.8821	0.8800
− 5.62	0.8788	0.8790	0.8791	0.8789	0.8777	0.8846	0.8828
− 2.00	0.8832	0.8832	0.8833	0.8831	0.8816	0.8865	0.8851
+ 1.57	0.8862	0.8860	0.8863	0.8858	0.8854	0.8883	0.8872
4.95	0.8882	0.8880	0.8882	0.8878	0.8879	0.8900	0.8891
9.02	0.8909	0.8907	0.8909	0.8912	0.8907	0.8921	0.8914
14.28	0.8943	0.8942	0.8944	0.8944	0.8942	0.8947	0.8943
18.50	0.8962	0.8962	0.8962	0.8963	0.8961	0.8967	0.8965
21.25	0.8973	0.8973	0.8973	0.8973	0.8972	0.8978	0.8978
27.00	0.8999	0.8999	0.8999	0.8999	0.8999	0.8999	0.8999
29.55	0.9011	0.9011	0.9010	0.9010	0.9011	0.9011	0.9011
35.30	0.9037	0.9038	0.9036	0.9037	0.9037	0.9037	0.9036
40.25	0.9062	0.9064	0.9061	0.9062	0.9062	0.9061	0.9062
47.10	0.9101	0.9103	0.9095	0.9097	0.9102	0.9090	0.9092
56.30	0.9145	0.9146	0.9137	0.9142	0.9145	0.9132	0.9136
63.90	0.9187	0.9188	0.9182	0.9185	0.9186	0.9152	0.9173
70.00	0.9216	0.9217	0.9212	0.9213	0.9217	0.9187	0.9204

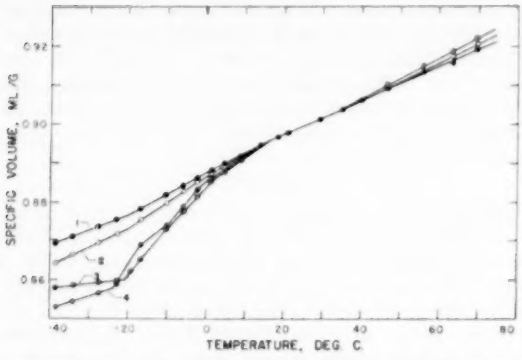

FIG. 1. Specific volume of peanut butter as a function of temperature for (1) Stabilized Peanut Butter B, (2) Stabilized Peanut Butter C, (3) Unstabilized Peanut Butter A, and (4) Stabilized peanut butter, preheated and rapidly cooled.

considerable melting had occurred, the apparent liquid range is relatively long. Melting was too slight to be detected, and hence can be disregarded. The expansion of both stabilized and unstabilized peanut butter in the temperature range 25 to 70°C.(77 to 158°F.), in which all of the free oil and any added stabilizer appeared to be entirely in the liquid phase, was found to be 0.00046 ml./gm./°C.

DISCUSSION

While the present data do not include all possible types of peanut butters and conditions of processing, they probably are representative of the general behavior of average peanut butters.

The stabilized butters, which had been heated to 80°C. prior to determination of their expansibilities, exhibited considerable melting below 25°C., unlike the same butters which had not been heat-treated. Preheating of the stabilized butters resulted in melting and dispersion of the added hydrogenated peanut oils (stabilizers) in the pre-existing free oil. In the unheated samples of the same peanut butters, the stabilizers were incompletely melted during processing and consequently both solid and liquid oil phases were present in the peanut butter prior to cooling to the initial temperature of the expansibility determinations. During cooling to the initial temperature, the continuous phase of the preheated butters would be expected to form a solid with a lower melting point than that of the original stabilizer used. As a result, the expansion of this solid would begin at a lower temperature and be greater than that of the original and higher melting stabilizer, and this was found to be the case.

Although the melting dilation of the stabilizing agents alone was appreciable from about 54 to 64°C.(129 to 147°F.), there was no indication in this temperature range of any melting in the peanut butter in which these materials were incorporated. However, since the weight of the added stabilizer is a very small percentage of the total weight of the peanut butter, and the melting range is extensive, lack of definite melting dilation of

the fat phase within the peanut butter is not surprising. No polymorphic changes in the crystal structures of the solid oil phase of the stabilized peanut butters were observed, irrespective of rates of cooling. Likewise, specific volumes of the stabilized and unstabilized peanut butters were very similar in the temperature range of 15 to 70°C.(59 to 158°F.), indicating that no polymorphic change occurred in the stabilized butters.

The action of a stabilizing agent in preventing separation of the oil from peanut butter does not seem to be the result of a change in the crystal structure of the fat phase. This phenomenon is more reasonably explained as a result of an intimate mixing and some solution of particles of the pre-existing crystal structure of the added hydrogenated fat in the free oil present in the peanut butter. The action of the added stabilizer can, therefore, be considered as analogous to that occurring during the chilling of a hydrogenated fat to form shortening or margarine, Bailey (1945). That both free oil and solid fat, and not a continuous oil phase, were present in the stabilized butters is substantiated by the fact that on subjecting such a butter to centrifugation, approximately seven per cent by weight of free oil was separated.

An advantage of cooling freshly ground peanut butter from the temperature at which it issues from the grinder, to the lowest possible temperature at which it can be packaged conveniently, would be to reduce shrinkage of the product in the package. It should be noted that in the temperature range of primary interest to the manufacturers of peanut butter, 20 to 60°C.(68 to 140°F.), the absolute specific volume of the product is a function of temperature, and the shrinkage of peanut butter on cooling can easily be calculated from the volume-temperature data.

SUMMARY

Peanut butter of three different compositions was subjected to dilatometric examination. From the data on expansibility and absolute density, the absolute specific volume of each peanut butter was calculated for various temperatures from −38.6 to 70.0°C.(−38 to 158°F.).

No evidence of polymorphic transformations was obtained, regardless of rates of cooling of the samples of peanut butter.

The reported data may be applied to the calculation of the shrinkage of peanut butter, which may occur after packaging as a result of natural cooling of the product to room temperature.

ACKNOWLEDGMENT

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NUTRITIVE VALUES OF SAUSAGE AND OTHER TABLE-READY MEATS AS AFFECTED BY PROCESSING

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Ready-to-eat meats which come under the classification of sausages[1] constitute an important part of the meat supplies of the American public. More than 1,500,000,000 pounds, including franks, bolognas, salamis, meat loaves, etc., are produced each normal year in government-inspected plants [U. S. Dept. of Commerce (1946)]. Estimates place this at 10 per cent of the total meat production of those plants.

While some table-ready meat products may be heated or cooked before serving, all except the fresh sausages are edible as sold and the great majority is eaten cold or with such mild warming that loss of nutrients is negligible. In these, changes from the raw meat occur only during the commercial processing operations, and sausage processing is very mild compared to many home and commercial cooking operations given meat prepared in other ways.

There are hundreds of individual items, but there are four general classes of sausages, based on the method of preparation, Jacobs (1944):

(1) Fresh sausage—(fresh pork or pork-and-beef sausages).
(2) Smoked and/or cooked sausage—(franks, bolognas, polish, Berliner, etc.).
(3) Dry sausage—
  (a) Semi-dry sausage (soft cervelat, Thuringer, soft salami, cooked salami, and mortadella).
  (b) Hard dry sausage (smoked dry salami and cervelat, peperoni, Italian uncooked salami, chorizas, mortadella, etc.).
(4) Products related to sausage (chili con carni, tamales, scrapple, meat loaves, etc.).

The individual items differ in kinds of meat used, nature of the grinding or chopping, presence or lack of curing ingredients, size and type of casing, use or lack of a smoking process, type of cooking operation, and in aging or drying schedules. Sausages are manufactured from boneless beef, lamb, and veal; pork shoulders or pork trimmings resulting from shaping hams, shoulders, and bacon. Edible variety meats, such as hearts and livers, are sometimes used. Milk powder and cereals when used in sausage are limited by state and federal regulations to three and one-half per cent.[2] Each item has a typical formula and processing schedule, but formulas for the different sausages vary from one manufacturer to an-

[1] Basically, all sausage is comminuted meat, and it may appear in many forms other than the conventional fresh "pork sausage."

[2] Some states prohibit the sale of sausage containing milk powder.

other in different sections of the country and, within certain limits, for each producer.

For each type of product the manufacturing operations involved are more or less standard and include some or all of the following steps:

(1) The selection and assembly of proper meats.
(2) Grinding or chopping to the desired texture.
(3) Incorporation of a curing mixture [5] and/or spices.
(4) Stuffing into casings or packing into forms.
(5) Smoking in chambers, using a smoking medium of hickory sawdust.
(6) Cooking, either in dry or humid ovens, in steam, or in vats of hot water.
(7) Aging and drying under controlled temperatures and humidities for some products.

A thorough investigation of each operation for each type of sausage would be extremely laborious. This has proved to be unnecessary, however, since the losses of nutrients during processing have been found to be relatively small and fairly constant for several different types of sausage, permitting generalizations for most types.

EXPERIMENTAL WORK

In investigating each of the products for which data are given at least two samples were taken, one of the raw mixture ready for stuffing into casings or cans, and one of the product when ready for sale. In several instances preliminary or intermediate steps were investigated. It has been reported previously by Rice and Robinson (1944) that curing mixtures containing salt, sugar, nitrate, and nitrite do not affect the vitamins of meat. This observation has been repeatedly confirmed in our laboratories. Hence, in reporting this series of investigations, only those operations subsequent to the mixing of the formula will be considered.

The products studied, their chief meat ingredients, and an outline of the processing schedule are given (Table 1). Ordinarily, sausages are cooked under closely specified conditions until the centers of the pieces reach a predetermined temperature. These are the cooking temperatures listed in the table. The processing schedules vary slightly with changes in formula or kind of meat, but the values given indicate the severity of treatment.

The temperatures and humidities of the smoke-ovens and the duration of the smoking operation are carefully controlled. For many products a gradual change of conditions is essential to proper processing. The temperatures listed (Table 1) for smoking treatment are the maximum air temperatures. Except for franks, the smoking period is sufficiently long to bring the product temperature approximately to the oven temperature. With franks, the product temperature reaches only 66 to 71°C.(150 to 160°F.) in the ovens.

The steps involved in the study of franks are illustrative of the sampling and analytical procedure. At the beginning of this test one lot of

[5] A typical curing formula: three lb. salt, four oz. cane sugar, three oz. nitrate, and one quarter oz. nitrite per 100 lb. of meat.

TABLE 1

Table-Ready Meats Investigated

Product	Principal meat ingredients	Nitrate-nitrite cure	Smoking treatment	Cooking treatment	Drying[2] period
			°F.	°F.	
Franks	Pork and beef	Yes	180°	Steam 150°	None
Bolognas					
(1st qual. large)	Pork and beef	Yes	None	Dry heat 155°	None
(Ring and long)	Pork and beef	Yes	None	Steam heat 155°	None
(2nd long)	Pork, beef, and variety meats[1]	Yes	None	Steam heat 155°	None
Braunschweiger	Pork, pork livers	Yes	120°	Steam 160°	None
Plain meat loaves	Beef, pork, and veal	Yes	None	Dry heat 155°	None
Meat, macaroni, and cheese loaf	Beef, pork	Yes	None	Dry heat 155°	None
Minced ham	Pork, beef, and pork cheeks	Yes	120°	Steam 150°	None
Cooked salami	Beef and pork variety meats	Yes	None	Dry heat 150°	None
Thuringer cervelat	Beef, beef variety meats	None	125°	None	None
Peperoni	Pork and beef	Yes	None	Dry heat 137°	14 days
Genoa salami	Pork	Nitrate only	None	None	87 days
Premium salami	Pork and beef	Yes	None	None	50 days
Franklin salami	Pork and beef	Yes	None	None	47 days
Impero Genoa salami	Pork and beef, pork cheeks	Nitrate only	None	None	82 days
H. C. cervelat salami	Beef and pork	Yes	100°	None	79 days
Lebanon bologna	All beef	Yes	Yes	Dry heat 128°	3-4 days

[1]Variety meats include hearts, livers, cheek and head trimmings. [2]This period permits curing of the meat and removal of from 20 to 40 per cent of its moisture. Ordinarily in a cooler at around 10°C.(50°F.).

previously mixed frank formula was selected. Samples of the raw mixture were obtained by collecting 30 raw franks at random during the stuffing of that mixture. Weights of the stuffed raw franks (hanging on racks) were taken and the product was then allowed to hang in a curing-room for several hours. When properly cured the franks were smoked, then steam cooked to an internal temperature of 66°C.(150°F.), and finally cooled. The finished franks were weighed and 30 were taken at random from the rack. The samples of raw and cooked franks were ground separately and assayed for moisture, protein, fat, thiamine, niacin, and riboflavin. Methods of the Association of Official Agricultural Chemists (1945) were used for the proximate analyses. Vitamin A analyses were made by the Carr-Price technique, thiamine was determined by the thiochrome tech-

nique, and riboflavin and niacin were determined microbiologically, using methods similar to those of the Association of Vitamin Chemists (1947).

Vitamin retentions were calculated on a lot basis, i.e., by comparing the vitamin content of the entire raw lot to the cooked lot, as described elsewhere by Rice, Beuk, and Fried (1947).

In many cases, for the purpose of checking, calculations were also made on a solids or protein basis. Retention values so obtained checked well with those obtained by the "totals" method. Analytical values for the finished products are listed (Table 2). Corresponding values were obtained for the raw mixtures, but these are of no interest other than as a base from which to calculate the nutrient retentions, which are listed (Table 3).

TABLE 2

Analyses of Table-Ready Meats

Product	H_2O	Protein	Fat	Thiamine	Riboflavin	Niacin
	pct.	*pct.*	*pct.*	*μg./g.*	*μg./g.*	*μg./g.*
Franks						
1st grade	56.8	14.03	24.3	0.94	2.41	31.2
2nd grade	49.4	11.16	35.0	0.94	2.00	18.1
Bologna, 1st grade						
Large	60.5	12.19	23.1	1.80	1.52	23.4
Long	58.9	11.94	24.5	1.82	1.60	25.5
Ring	58.2	12.94	25.0	1.93	1.65	25.4
Bologna, 2nd grade						
Large	68.0	15.44	11.0	1.04	3.70	28.2
Ring	66.6	15.75	11.4	1.27	3.70	27.7
Braunschweiger[1]	61.8	15.81	19.1	2.65	15.15	83.1
Meat loaf	65.1	12.63	10.3	1.3	2.25	25.2
Meat, macaroni, and cheese loaf	59.3	12.31	11.0	1.86	2.43	23.3
Minced ham	63.2	14.9	16.6	3.66	2.25	34.0
Cooked salami	.....	.....	.....	2.24	3.73	42.4
Thuringer cervelat	54.0	14.38	25.3	1.07	3.07	43.7
H. C. cervelat	.....	.....	.....	2.69	2.30	54.8
Peperoni	.....	.....	.....	1.92	3.11	50.7
Salamis						
Premium Genoa	.....	.....	.....	3.65	2.59	45.4
Premium	32.9	21.94	38.9	5.25	2.86	58.2
Franklin	27.5	21.19	44.3	2.75	2.30	52.0
Impero Genoa	.....	.....	.....	3.22	2.34	56.6
Lebanon bologna	62.4	21.88	9.8	0.36	2.40	48.2

[1] Vitamin A content of Braunschweiger, determined by the Carr-Price method, was 259 U.S.P. units per gm.

DISCUSSION

The actual nutrient contents of table-ready meats obviously vary with the meats used in their formulation, and the data (Table 2), therefore, represent only one typical formula. That these are highly nutritious meat products is amply indicated by the data. It is interesting to note that most of the meats used in preparing these products fall into three catagories: trimmings, which are cut away from standard meat (such as hams) to give them a more uniform shape; variety meats such as hearts and livers; and meats which are exceptionally lean, e.g., cow and bull meat. These

TABLE 3

Nutrient Retentions During Processing

Product	Nitrogen	Thiamine	Riboflavin	Niacin
	pct.	*pct.*	*pct.*	*pct.*
Franks				
High quality	100	98	104	95
Low quality[1]	96	86	101	97
Bologna				
1st quality ring	.....	92	95	99
1st quality long	.....	89	94	101
1st quality large	.....	91	94	97
2nd quality ring	.....	102	101	89
2nd quality large	.....	85	105	95
Braunschweiger[2]	99	81	95	89
Meat loaf	100	94	95	102
Meat, macaroni, and cheese loaf	103	78	97	107
Minced ham	.....	90	101	95
Cooked salami	.....	86	96	94
Thuringer cervelat	98	86	96	.....
H. C. cervelat	.....	83	83	92
Peperoni	.....	74	95	89
Salamis				
Genoa	.....	81	104	105
Premium	96	83	97	98
Franklin	100	81	89	98
Impero Genoa	.....	98	84	106
Lebanon bologna	108	72	96	102

[1]This formula was intentionally made quite inferior in order to obtain data of several grades. Franks of this grade seldom reach the market. [2]Ninety-eight per cent of the vitamin A in Braunschweiger was retained after processing.

meats would be relatively undesirable as fresh cuts, such as retailers sell to consumers. However, they are all wholesome products, and can be combined to yield the great variety of palatable and distinctively flavored table-ready meats now on the market. Furthermore (as Table 3 illustrates), most of the nutrients have been almost completely retained. The most noticeable loss has been that of thiamine, which decreased by amounts varying from two to 26 per cent during processing of the various items. Even the semi-dry sausages which are processed slightly show small losses of this vitamin. The other changes are so slight and variable that most can be attributed to experimental variation.

These slight processing losses are in marked contrast to those which would occur if the meats were cooked directly by regular home or restaurant methods, because much of the raw material is suitable only for stewing or pot-roasting. These methods of cookery result in large losses of nutrients, especially if the juices are not completely utilized. Even when both meat and broth are used, those methods of cooking permit retention of only 40 to 60 per cent of the thiamine, Cover and Dilsaver (1947). If the broth is discarded or only partially used, loss of thiamine would be even greater and there would also be waste of the heat-stable vitamins and of protein.

Although table-ready meats need not be cooked, some of them are warmed before using, especially franks. Cooking conditions are so mild, however, that losses of nutrients are so slight as to be of doubtful sig-

nificance (Table 4), unless the meats are unnecessarily overcooked by prolonged stewing or boiling. Similar findings were reported by Tauber and Lloyd (1947). The franks used in these present studies were of first quality. Poorer grades of franks show higher losses, primarily due to greater shrinkage and loss of fat and water-soluble nutrients. With high quality franks so little is leached into the cooking water that detection of the individual nutrients is almost impossible.

Bologna, braunschweiger, and franks were stored at refrigerator temperatures for time intervals ranging from 12 days for the franks to 30 days for the bologna and braunschweiger, and then reassayed. No significant changes were found in the vitamin contents of the stored products.

TABLE 4

Changes in Franks During Cooking

Type of cook	Type of casing	Weight yield	Retention of vitamins		
			Thiamine	Riboflavin	Niacin
			pct.	pct.	pct.
Broiled[1]	Sheep casing	96	94	107	104
Broiled[1]	Viscose casing	97	94	112	108
Recommended method[2]	Sheep casing	99	86	108	99
Recommended method[2]	Viscose casing	99	95	112	96
Boiled[3]	Sheep casing	99	86	86	86
Boiled[3]	Viscose casing	99	86	88	88

[1]Broiled at 177 to 191°C.(350 to 375°F.) for a total of eight minutes, four minutes on each side. [2]The franks were dropped into boiling hot water for eight minutes and then allowed to cool to 77°C.(170°F.) in the cooking water. [3]Boiled for 20 minutes and allowed to cool slowly to 77°C. (170°F.) in the cooking water.

SUMMARY

The thiamine, riboflavin, and niacin contents of 15 different types of sausage or table-ready meats have been determined and compared to corresponding values for the raw products from which they have been made. No consistent loss of riboflavin or niacin was observed, most variations being well within the range of experimental variation. Slight losses of thiamine (two to 26 per cent) occurred in manufacture of these products.

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RELATION OF VARIETY AND LOCALITY TO NIACIN, THIAMINE, AND RIBOFLAVIN CONTENT OF DRIED BEANS GROWN IN THREE YEARS

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Wide ranges in the reported composition of plant foods indicate that conditions under which the plant is grown influence its composition. In the last few years, considerable work has been done in this laboratory on relation of locality to the composition and cooking quality of dried beans. Part of this study has been concerned with niacin, thiamine, and riboflavin, and has shown very definite trends.

Numbers are used in the following tables to designate the kinds of beans: 295, 641, and 2574 are strains of pinto beans, and 2534 is a pinto-calico hybrid.

Bean samples utilized for this study were grown under different types of farming (Table 1), some being irrigated and others grown without irrigation. The altitudes of the localities range from 3,900 to 6,300 feet.

EXPERIMENTAL PROCEDURE

The original plan of work was to include eight varieties of beans from four widely differing localities in New Mexico, for three years. However, many of the samples were not obtainable at harvest time and it has, therefore, been necessary to treat the data regarding locality differences on the basis of one year, and the data regarding year differences on the basis of one locality.

Niacin was determined microbiologically, thiamine by the thiachrome method, and riboflavin by the fluorometric method, with modifications of the original methods as suggested by the Association of Vitamin Chemists (1947). Riboflavin was also determined microbiologically according to the A.V.C., as a check on the fluorometric method.

DISCUSSION OF RESULTS

Analysis of variance of the data, Snedecor (1946), showed highly significant differences in niacin values (Tables 2 and 6) of the varieties of beans studied. Years also had a significant effect on niacin values (Table 6). Differences due to locality (Table 2) are even greater than variety or year differences, beans from Estancia having the greatest values and those from Deming the lowest. Within localities, the Michelite showed the highest niacin value and Red Mexican the lowest.

Significant differences in thiamine values due to variety, location, and year are shown (Tables 3 and 7), locality differences again being greater than variety or year differences. Thiamine values, like niacin, were highest for Estancia beans and lowest for those from Deming.

TABLE 1

Type of Farming Area Where Beans Were Grown

Locality	Altitude	Dry farming or Irrigation
	ft.	
Deming	4,300	Irrig. from wells
Estancia	6,300	Dry farming
State College	3,900	Irrig. from Rio Grande River

TABLE 2

Niacin Values of Eight Varieties of Dried Beans Grown at Three Different Localities in New Mexico in 1949 [1]

Variety	Localities			Mean [2]
	Deming	Estancia	State College	
Navy	32.6	33.9	28.9	28.5
Pinto 2574	18.9	32.0	26.4	25.8
Calico	19.5	31.4	25.0	25.3
Pinto 641	20.5	33.8	25.4	26.6
Hybrid 2534	20.5	32.3	25.2	26.0
Red Mexican	18.3	28.6	25.0	24.0
Pinto 295	20.0	31.4	26.3	25.9
Michelite	28.5	34.4	34.8	32.6
Mean [3]	21.1	32.2	27.1	

[1] Expressed as μg. per gm. on dry-weight basis. [2] Differences significant at the one per cent level. Least significant difference equals 2.2 μg. [3] Differences significant at the one per cent level. Least significant difference equals 3.6 μg.

TABLE 3

Thiamine Values of Eight Varieties of Dried Beans Grown at Three Different Localities in New Mexico in 1949 [1]

Variety	Localities			Mean [2]
	Deming	Estancia	State College	
Navy	9.9	13.6	10.6	11.4
Pinto 2574	9.5	14.8	12.8	12.4
Calico	8.4	11.4	10.6	10.1
Pinto 641	9.7	14.3	12.4	12.1
Hybrid 2534	8.3	11.3	11.4	10.3
Red Mexican	8.8	11.0	10.2	10.0
Pinto 295	9.5	15.0	11.5	12.0
Michelite	10.4	14.8	10.7	12.0
Mean [3]	9.3	13.3	11.3	

[1] Expressed as μg. per gm. on dry-weight basis. [2] Differences significant at the one per cent level. Least significant difference equals 1.3 μg. [3] Differences significant at the five per cent level. Least significant difference equals 1.6 μg.

TABLE 4

Riboflavin Values of Eight Varieties of Dried Beans Grown at Three Different Localities in New Mexico in 1949[1]

Variety	Localities			Mean[2]
	Deming	Estancia	State College	
Navy	2.2	2.5	2.4	2.4
Pinto 2574	1.9	2.4	2.4	2.2
Calico	2.2	2.4	2.4	2.3
Pinto 641	1.9	2.3	2.2	2.1
Hybrid 2534	2.2	2.5	2.6	2.4
Red Mexican	2.0	2.4	2.2	2.2
Pinto 295	1.9	2.3	2.2	2.1
Mean[2]	2.0	2.4	2.3	

[1] Expressed as μg. per gm. on dry weight basis. [2] Differences significant at the one per cent level. Least significant difference equals 0.1 μg. [2] Differences significant at the one per cent level. Least significant difference equals 0.2 μg.

TABLE 5

Mean Squares for Eight Varieties of Dried Beans Grown at Three Different Localities in New Mexico in 1949[1]

Source of variation	Degrees of freedom	Mean squares		
		Niacin	Thiamine	Riboflavin
Total	23	.....	.....	.....
Localities	2	248.0[1]	31.4[1]	0.28[1]
Varieties	7	21.0[2]	2.9[2]	0.039[1]
Interaction	14	2.2	0.79	0.005

[1] Differences significant at the one per cent level. [2] Differences significant at the five per cent level.

TABLE 6

Niacin Values of Eight Varieties of Dried Beans Grown at Deming, New Mexico, in 1947, 1948, and 1949[1]

Variety	Years			Mean[2]
	1947	1948	1949	
Navy	28.9	25.1	22.6	25.5
Pinto 2574	22.1	23.4	18.9	21.5
Calico	21.9	20.3	19.5	20.6
Pinto 641	24.2	22.3	20.5	22.3
Hybrid 2534	24.6	22.1	20.5	22.3
Red Mexican	20.7	20.2	18.3	19.7
Pinto 295	24.8	22.0	19.8	22.2
Michelite	31.5	29.8	28.5	29.9
Mean[2]	24.8	23.3	21.1	

[1] Expressed as μg. per gm. on dry weight basis. [2] Differences significant at the one per cent level. Least significant difference equals 1.4 μg. [2] Differences significant at the one per cent level. Least significant difference equals 2.0 μg.

TABLE 7

Thiamine Values of Eight Varieties of Dried Beans Grown at Deming, New Mexico, in 1947, 1948, and 1949 [1]

Variety	Years			Mean [2]
	1947	1948	1949	
Navy	9.4	8.4	9.9	9.2
Pinto 2574	8.7	8.8	9.5	9.0
Calico	8.1	7.7	8.4	8.1
Pinto 641	9.5	9.4	9.7	9.5
Hybrid 2534	8.7	7.1	8.3	8.0
Red Mexican	8.0	7.6	8.8	8.1
Pinto 295	9.1	8.5	9.5	9.0
Michelite	10.1	9.4	10.4	10.0
Mean	9.0	8.4	9.3	

[1] Expressed as μg. per gm. on dry-weight basis. [2] Differences significant at the one per cent level. Least significant difference equals 0.5 μg. [3] Differences significant at the one per cent level. Least significant difference equals 0.7 μg.

TABLE 8

Riboflavin Values of Eight Varieties of Dried Beans Grown at Deming, New Mexico, in 1947, 1948, and 1949 [1]

Variety	Years			Mean [2]
	1947	1948	1949	
Navy	2.1	2.3	2.2	2.2
Pinto 2574	1.9	2.0	1.9	1.9
Calico	2.0	2.0	2.2	2.1
Pinto 641	1.8	1.9	1.9	1.9
Hybrid 2534	2.2	2.3	2.2	2.2
Red Mexican	2.0	1.9	2.0	2.0
Pinto 295	1.9	2.0	1.9	1.9
Michelite	2.0	2.0	2.0	2.0
Mean [3]	2.0	2.0	2.0	

[1] Expressed as μg. per gm. on dry-weight basis. [2] Differences significant at the one per cent level. Least significant difference equals 0.2 μg.

TABLE 9

Mean Squares for Niacin, Thiamine, and Riboflavin Values of Dried Beans Grown at Deming, New Mexico, in 1947, 1948, and 1949

Source of variation	Degrees of freedom	Mean squares		
		Niacin	Thiamine	Riboflavin
Total	23	.....	.....	.....
Years	2	28.4[1]	1.8[1]	0.005
Varieties	7	32.1[1]	1.6[1]	0.05[1]
Interaction	14	0.9	0.093	0.005

[1] Differences significant at the one per cent level.

Differences in riboflavin due to variety and location were highly significant (Table 4), but were not as great as differences in the other two vitamins studied, especially niacin. Years had no significant influence on riboflavin content (Table 8). Beans from Estancia and State College were higher in riboflavin than those from Deming. Within localities, Hybrid 2534 and navy beans showed higher riboflavin values than the others analyzed.

SUMMARY

Analyses of eight varieties of beans grown in three widely differing localities showed that environmental conditions had a greater influence on niacin, thiamine, and riboflavin content of dried beans than did the variety. Variety differences, however, were highly significant. Beans grown at Estancia showed higher vitamin values than those from the other places studied. The environmental conditions responsible for this variation are not known. Work is now in progress in this laboratory to determine the difference in vitamin content of dried beans due to the growing season. It is suggested that a further study be made on the influence of such factors as soils, altitude, temperature, growing season, and irrigation water on the composition of beans.

ACKNOWLEDGMENT

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SOME EFFECTS OF SALT AND MOISTURE ON RANCIDITY IN FATS[1]

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Sodium chloride has been shown to have an accelerating effect on rancidity in frozen pork, Dubois and Tressler (1943), Wiesman and Ziemba (1946), and Watts and Peng (1947a); in cured pork, White (1941); and in fish, Banks (1937). On the other hand, Lea (1939) cited several studies in which sodium chloride solutions either had no effect or actually inhibited rancidity in various foods. He concluded that sodium chloride itself is probably not a prooxidant but that it promotes the activity of unsaturated fat oxidases present in meat and fish.

Lea (1939) also reviewed the literature on the influence of moisture on oxidative rancidity. Most powdered foods, crackers, and other cereal foods become rancid more readily when moisture is reduced to very low values. On the other hand, moisture was shown to have an accelerating effect on the oxidation of lard. It is difficult to draw any general conclusions, since results may be complicated by the fact that moisture may influence bacterial action and solubility of accelerators or inhibitors.

In preliminary experiments in this laboratory it was observed that the effect of sodium chloride on fat oxidation depended greatly on the amount of moisture present in the system. With the thought that this interrelationship between sodium chloride and moisture might serve as an explanation for some of the conflicting results in the literature, the effect of sodium chloride and moisture on rancidity was further explored in both aqueous lard systems and fat systems containing muscle extract or its effective constituent—hemoglobin.

EXPERIMENTAL PROCEDURE

The filter paper technique developed in this laboratory, Scarborough and Watts (1949), for testing antioxidants in aqueous fat systems, was generally followed. Pure lard with or without the addition of primary antioxidants (alpha tocopherol or nordihydroguaiaretic acid) was used as the fat phase. Sodium chloride was introduced into the aqueous phase. Hemoglobin solutions or muscle extracts, prepared according to Watts and Peng (1947b), were also added to the aqueous phase. All sample dishes were sealed with paraffin wax to prevent loss of moisture, and incubated at 50°C.(122°F.). They were analyzed for peroxide number when they showed signs of oxidation. A peroxide value of 20 millimols per 1,000 gm. fat was arbitrarily selected as the end of the induction period, and the time required for any system to reach this point was used as a measure of its susceptibility toward oxidation.

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RESULTS

Effect of Dry Sodium Chloride: Sodium chloride solutions at molar concentration had little effect or slight inhibition on lard oxidation, as compared with controls containing no salt but otherwise identical. However, if this sodium chloride solution was first dried on filter papers before bringing into contact with fat, appreciable acceleration was obtained in comparison with controls in which water alone was dried on the paper.

The same amount of crystalline sodium chloride sprinkled on the surface of filter paper impregnated with lard also showed an accelerating effect, although to a smaller degree, presumably because of the smaller surface of contact between salt and fat.

This accelerating effect of dry salt was found true in lard containing added tocopherol or nordihydroguaiaretic acid (N.D.G.A.), as well as in pure lard. Results are summarized (Table 1).

TABLE 1

Effect of Moisture on Behavior of Sodium Chloride in Autoxidation of Lard

Experimental condition	Time to turn rancid at 50°C. (122°F.)		
	Pure lard	Lard + 0.005% tocopherol	Lard + 0.005% N.D.G.A.
	hr.	*hr.*	*days*
Water alone	60	100	11
Molar NaCl solution	65	120	9
Water dried on filter paper	170	425	27
Molar NaCl dried on filter paper	75	130	13
NaCl sprinkled on fat	125	200	23

Effect of Concentrations of Sodium Chloride Below Saturation: When sodium chloride solutions at concentrations below saturation, i.e. two, five, 10, 15, and 20 per cent, were brought into contact with lard, inhibition at lower concentrations and acceleration at higher concentrations were observed repeatedly. A group of curves showing such a relationship, which was obtained with four different samples of lard, is presented (Fig. 1). In all curves, concentrations below five per cent inhibited, and above 15 per cent accelerated, oxidation.

Effect of Progressive Removal of Moisture From Dilute Sodium Chloride Solutions: Very marked acceleration of rancidity was obtained when dilute sodium chloride solutions were partially dried on filter paper before bringing into contact with the fat. In a typical experiment, one-ml. aliquots of a 10 per cent salt solution were absorbed on filter papers, and the moisture removed to various degrees by drying at 50° C. (122° F.). Moisture removed from each sample was calculated from its weight loss. After introduction of fat phase, the samples were incubated at 50°C. for 48 hours. All samples were then analyzed for peroxide and results were plotted against moisture content (shown Fig. 2).

By a comparison of the two curves, it is clear that as moisture was removed sodium chloride first inhibited and then hastened oxidation. The calculated saturation point of sodium chloride solution occurs at the point where 73 per cent of the original moisture is removed. The curve showed

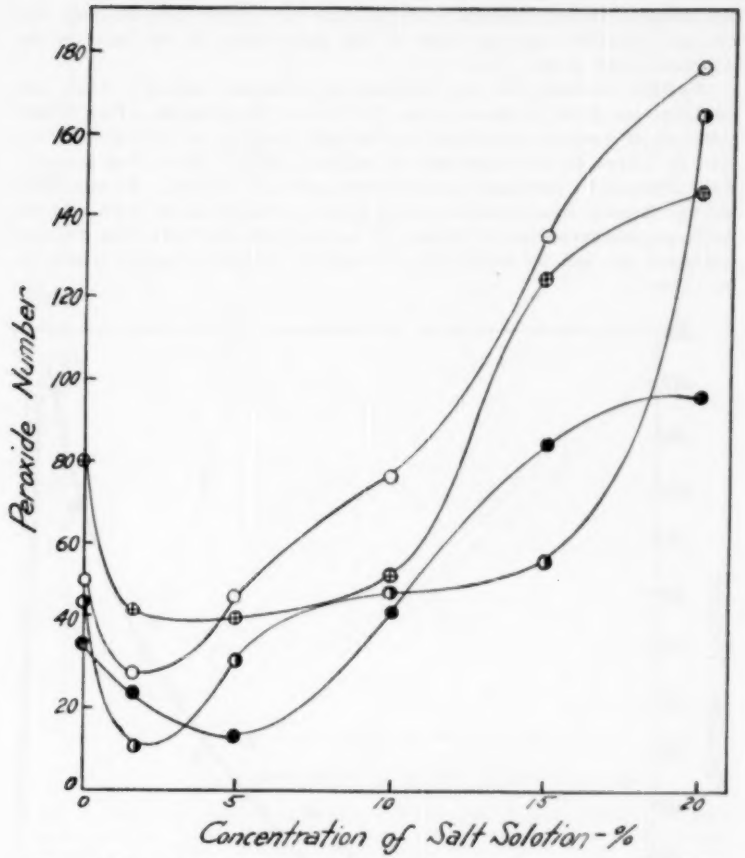

FIG. 1. Effect of salt solutions on rancidity in lard. Each curve represents a different sample of lard in contact with various concentrations of salt. Temperature = 50°C. (122°F.). Time of analysis varied with each curve.

no inflection at this point, but irregular drying of filter paper may throw some of the sodium chloride crystals out of solution, even when total moisture content of the system is sufficient to dissolve all the sodium chloride. Also, paper fibers may compete with salt for the water present and thus make the concentration of sodium chloride actually higher than its calculated value.

The effect of the salt solution changed from inhibition to acceleration only generally as the moisture content was diminished. It reached a peak near the dry end but dropped sharply when moisture was completely removed. Crystals were visible on the surface of filter paper for the very

dry samples, which decreased the surface of contact between salt and fat, and probably was the cause of the sharp drop of the curve at the completely dry point.

Further evidence for the accelerating effect on rancidity when salt solutions are dried is shown (Fig. 3). Curve A shows the effect of salt solutions of various concentrations brought directly in contact with the fat. In Curve B, concentrations of sodium chloride above two per cent were obtained by partially drying the two per cent solution. At equivalent sodium chloride concentrations, much higher peroxide values were obtained with samples prepared by drying, in spite of the fact that these samples contained less salt by weight when compared with corresponding samples on Curve A.

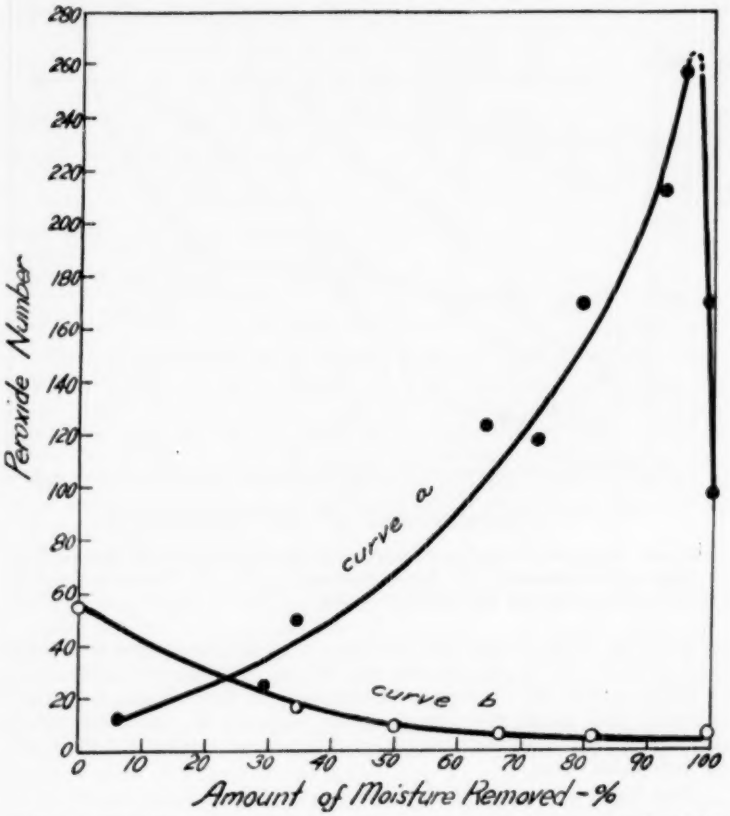

FIG. 2. Rancidifying effect of removing moisture from a 10 per cent salt solution absorbed on filter paper. Curve *a* represents a 10 per cent sodium chloride solution; Curve *b*, water.

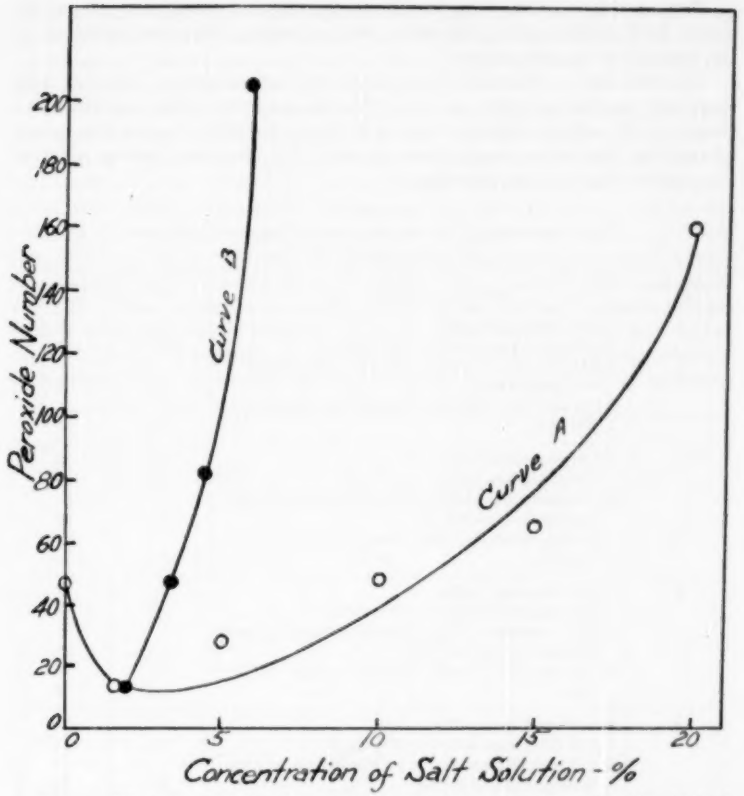

FIG. 3. Effect on rancidity of various concentrations of sodium chloride obtained by direct solution (Curve A), versus drying a two per cent solution on filter paper (Curve B).

Effect of Sodium Chloride on Fat Oxidation in Presence of Hemin Catalyst: Sodium chloride solutions, in the presence and absence of hemoglobin or muscle extract, were buffered to prescribed pH with phosphate buffer in various experiments and their effect on lard oxidation compared (Table 2). In the presence of buffer, sodium chloride at five per cent concentration gave an acceleration, although it showed slight inhibition in the absence of buffer. Contrary to reports in the literature, sodium chloride showed no greater accelerating effect on rancidity in the presence of hemoglobin or muscle extract than in their absence. In fact, slight inhibition was ordinarily obtained with five per cent sodium chloride.

Variations of pH did not change the general picture; five per cent sodium chloride inhibited the catalytic power of muscle extract at all pH's investigated (5.2, 5.6, and 7.0).

Ten per cent sodium chloride, in the presence of muscle extract, accelerated lard oxidation, but the effect was no greater than that obtained in the absence of muscle extract.

Experiments to Eliminate Possibilities of Contamination: Metallic ions, especially copper and iron, are powerful prooxidants in fat oxidation. Although C. P. sodium chloride was used, it was thought possible that traces of metallic impurities might be responsible for the accelerating effect of this salt at higher concentrations.

TABLE 2

Effect of Sodium Chloride on Hemin Catalyzed Oxidation of Lard at 50°C.(122°F.)

Experiment No.	Solution in contact with lard	pH	Hours to turn rancid
1	0.1 M phosphate buffer	6.6	30
	0.1 M phosphate buffer + 5% NaCl	6.6	16
	0.1 M phosphate buffer + hemoglobin solution (0.2 gm./100 ml.)	6.6	5
	0.1 M phosphate buffer + hemoglobin solution + 5% NaCl	6.6	5
2	0.1 M phosphate buffer	5.6	45
	0.1 M phosphate buffer + 5% NaCl	5.6	41
	0.1 M phosphate buffer + muscle extract (0.2 gm. hemoglobin per 100 ml.)	5.6	10
	0.1 M phosphate buffer + muscle extract + 5% NaCl	5.6	18
3	0.1 M phosphate buffer	5.2	68
	0.1 M phosphate buffer + 5% NaCl	5.2	56
	0.1 M phosphate buffer + muscle extract (0.2 gm. hemoglobin per 100 ml.)	5.2	10
	0.1 M phosphate buffer + muscle extract + 5% NaCl	5.2	12
4	0.1 M phosphate buffer	7.0	46
	0.1 M phosphate buffer + 5% NaCl	7.0	36
	0.1 M phosphate buffer + muscle extract (0.2 gm. hemoglobin per 100 ml.)	7.0	15
	0.1 M phosphate buffer + muscle extract + 5% NaCl	7.0	14
5	Muscle extract (0.2 gm. hemoglobin per 100 ml.)	5.6	7
	Muscle extract + 10% NaCl	5.6	6
	0.1 M phosphate buffer + muscle extract	5.6	9
	0.1 M phosphate buffer + muscle extract + 10% NaCl	5.6	8

Several reagents have been reported to inhibit the prooxidant effect of metals. Cyanide was found to be effective in removing very small concentrations of copper from solution, Lea (1936), and sorbitol counteracted the effect of traces of both copper and iron in dry fats, Dutton, Schwab, Moser, and Cowan (1948). The addition of either of these reagents (0.1 per cent cyanide and 0.5 per cent sorbitol) did not reduce the acceleration obtained from sodium chloride at high concentrations or on drying. However, these experiments are inconclusive, since, when the metal-combining power of these reagents was tested with known amounts of added copper

or iron salts under our experimental conditions, sorbitol had no effect on either metal, while cyanide showed no effect on iron and only a slight inhibition of the copper catalyzed oxidation. About equal inhibition was obtained in water controls with no copper.

A further effort to eliminate the possibility that metal contamination was a factor in the salt experiments was carried out as follows: Five portions of crystalline sodium chloride weighing 10, 15, 20, 25, and 30 gm. were added to beakers containing 10 ml. of distilled water. The mixtures were stirred occasionally over several hours to make sure of the solution of all soluble substances present as impurities in the salt crystals. Five ml. of the supernatant saturated sodium chloride solution were pipetted out from each mixture and diluted to a final concentration of 15 per cent. These solutions were then identical in sodium chloride concentration but presumably different in soluble impurities. When their effect on fat oxidation was followed all showed acceleration with no appreciable differences. Thus, it seemed safe to conclude that metal ions in sufficient

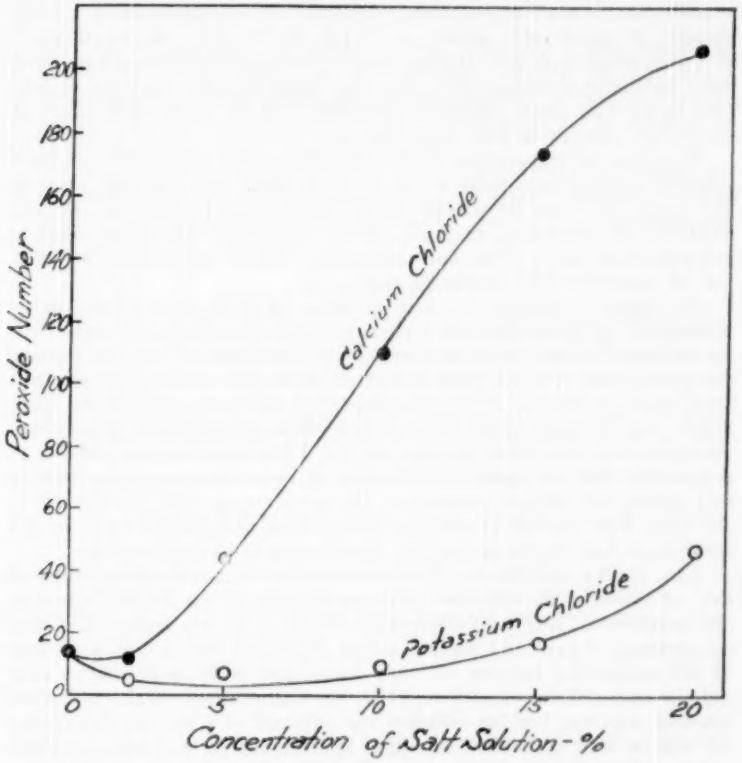

FIG. 4. Effect on rancidity of various concentrations of potassium and calcium chlorides.

quantity to cause an acceleration of fat oxidation were not present in the salt used.

Effect of Salts Other Than Sodium Chloride on Fat Oxidation: Solutions of potassium chloride and calcium chloride at concentrations ranging from zero to 20 per cent were brought into contact with fat and incubated following the usual procedure. Their behavior was similar to that of sodium chloride, except that calcium showed a higher degree and potassium chloride a lower degree of acceleration than sodium chloride. The possibility that metallic impurities in the calcium chloride might be a factor was not eliminated. Results are presented (Fig. 4).

DISCUSSION

Lea (1936) reported that the oxidation of lard films kept under sodium chloride solutions up to a concentration of 26 per cent was not accelerated. Results obtained in this laboratory, on the contrary, showed prooxidant activity of sodium chloride solutions above 15 per cent, when salt solution and lard were brought into contact by absorbing on filter paper. It is possible that in Lea's experiments, where the fat was immersed in a large quantity of liquid, the amount of oxygen dissolved in the liquid could have been much more of a limiting factor than in the experiments reported here. Solubility of oxygen decreases with increasing concentration of salt. This factor may have completely overshadowed the prooxidant effect of the sodium chloride in Lea's experiments.

Whatever the explanation of the differences noted in the effect of NaCl solutions on rancidity, there seems to be no doubt that dry salt brought into contact with fat invariably causes acceleration of rancidity. Experiments in this laboratory, in which various amounts of salt were added to prepared flour mixes (flour and shortening), showed progressive acceleration of rancidity with increasing salt.

Particularly conducive to rapid oxidation of fat is the condition where a complex food containing salt is partially or completely dehydrated. Here the salt may become widely and intimately mixed with the fat throughout the food, giving a much greater surface of contact between fat and salt than would be the case if the same amount of salt were added to the dehydrated food in crystal form. The adverse effects of processing cereal flakes containing salt have been pointed out by Wilder and Lindow (1937). It is probable that the partial dehydration of brined meats during smoking and subsequent storage exaggerates the accelerating effect of the salt in the cure. The practice of soaking potato chips and similar foods in salt solutions before frying in deep fat would seem to be questionable.

Lea (1937) and Banks (1937) attributed the accelerating effect of salt on rancidity in meat and fish, respectively, to its indirect effect on the unsaturated fatty acid oxidases contained in animal tissues. Lea used an emulsion of lard and pressed muscle juice and Banks used a mixture of fish muscle and herring oil. Both found that addition of sodium chloride in concentrations less than 10 per cent accelerated oxidation. In the research reported here no evidence was obtained of a specific acceleration by salt on lard oxidations catalyzed by dissolved hemoglobin or muscle extract, although the accelerating effect of sodium chloride on rancidity in frozen meats has been well established.

The freezing process, like partial drying, would have the effect of concentrating the salt, and further concentration through surface loss of moisture would take place under most packaging conditions. However, if the accelerating effect of salt on rancidity in frozen pork is due simply to the concentration of salt by freezing, salt would be expected to accelerate rancidity in cooked as well as raw pork.

There is the further possibility that salt may affect the physical state of meat in such a way that hemoglobin would be brought into closer contact with the fat. The apparent discrepancies between present results and the earlier work of Lea and of Banks may be traceable to differences in the muscle preparations used. The press juices or minced muscle tissues used by Lea and Banks, respectively, probably contained formed muscle elements or fragments and might, therefore, be expected to act more like meat than the clear filtrates used in the present study. Attempts to test the effect of salt on fresh meats not preserved by freezing were not successful, since bacterial action could not be prevented by any preservative tried.

SUMMARY

Dry sodium chloride and sodium chloride solutions at high concentrations behaved as prooxidants in fat oxidation. Calcium chloride had a much greater accelerating effect than sodium chloride. Potassium chloride had very little effect. Partial or complete dehydration of salt solutions in contact with fat greatly accelerated rancidity.

Sodium chloride did not specifically affect the activity of solutions containing unsaturated fat oxidase (hemoglobin and muscle extract). Possible explanations for the accelerated rancidity in frozen or cured meats by sodium chloride are discussed.

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CHICKEN FLAVOR: SEPARATION AND CONCENTRATION OF ITS VOLATILE COMPONENTS FROM BROTH

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Knowledge of the properties and identity of the compounds which impart flavor to chicken, or to any meat stock, is very scant.

Extended study of the meat flavor by many investigators has produced very little information. It has been suggested that the flavor of meat broths and chicken broth is due to monosodium glutamate or related compounds, Salomon (1943). It will be shown later why this cannot be so. Other substances must play an important part.

In his review on meat flavor, Crocker (1948) only briefly mentions the odoriferous principles present in meat flavor. Still, flavor chemists insist that odor and volatility are the most important characters in flavor, Moncrieff (1944).

In a note on chicken flavor the author, Bouthilet (1949), emphasized the importance of pH in chicken flavor, and suggested the use of ion exchange in flavor extraction.

In the following discussion of flavor fractionation, experiments and results will be lumped together, since the difficulties involved in the fractionation serve to illustrate some of the properties of the flavor.

In discussions there is often mentioned "flavor development;" this point is very important. A pH of 5.8 was found to elicit a continuous savory odor from cooking chicken, and it was assumed that the flavor was most volatile at this pH, Bouthilet (1949). However, when some fractions were prepared by methods which will be described, it was found that no odor was present but that the flavor could be tasted. Obviously one could not taste fractions such as mercury salts, but when these fractions were developed with monobasic potassium phosphate (KH_2PO_4) their flavor "developed" into a volatile compound which could be detected by sniffing. Sodium chloride had no such reaction and it was assumed that it was a pH, rather than a "salting-out," effect.

Experiment No. 1. *Methods of Determining Concentration of the Flavor*

Several methods were available for determination of the concentration of the flavor in liquid samples. The most satisfactory procedure was use of organoleptic methods. The samples were diluted serially before and after treatment, and tested both by tasting and by sniffing after development. The dilutions were prepared by placing 10 cc. of the original broth and 10 cc. of the concentrate in adjacent beakers. Then one cc. of each was removed and placed in subsequent beakers containing nine cc. of distilled water. Again one cc. of the diluted sample was removed and placed in a subsequent beaker; this process was carried on for 10 dilutions in each case. This would then give a final dilution of one billionth the original broth. Each sample was tasted, then developed and sniffed. Start-

ing from the highest dilution one could discover the level at which the odor or taste could be first detected. If the flavor could be detected at a dilution of 1/100th but not at 1/1000th, one could be reasonably sure that the limit of detection was somewhere between. Then by again diluting the 1/100th sample, this time 1/100th, 1/200th, 1/300th, and so on, one could determine the approximate concentration of the flavor in the sample. When fractions were compared by this dilution procedure, the concentration of flavor in any solution could be determined.

The second method for determining the concentration of flavor in fractions compared closely with the serial dilution method, but was not quite as satisfactory in every analysis. This was by the reaction of heavy metals with the flavor. By addition of silver, mercury, or lead salts a precipitate was formed which was in direct proportion to the flavor concentration in the liquid. Addition of these heavy metal salts also incurred a complete removal of the flavor from the liquid. The precipitate could be filtered off and weighed for quantitative determination.

Lastly, one could follow the flavor concentration by a total sulfur determination on the distillates. The sulfur content followed the flavor concentration as determined by serial dilution. The analysis for sulfur had to be done in a sealed Carius tube, as the oxidation acids volatilized the product if done in an open vessel.

Experiment No. 2. *Preparation of a Basal Medium for Tasting of Flavor Extracts*

For organoleptic analysis of the fractions it was found necessary to have a medium to add the flavor to simulate the nonvolatile chemical and physical properties of chicken broth. This "basal" was designed to duplicate that portion of the broth which one tastes when he takes a little broth into his mouth and swallows while holding his nose. Such a procedure can be used to differentiate a true flavor from a sensation or a taste. The basal produced was nearly identical to a broth tasted in such a fashion. The basal was prepared by first determining the amount of nonprotein nitrogen and protein nitrogen in a sample of chicken broth, made as described in the section on chicken broth; then a solution was prepared of monosodium glutamate equal to nonprotein nitrogen, gelatin equal to protein nitrogen, and a dye. This basal had the same consistency as chicken broth.

This solution contained

1 gm. MSG
3/4 gm. gelatin
5 cc. of a dye basal[1]
95 ml. of water

Experiment No. 3. *Chicken Broth*

An experiment was designed to determine the best way to prepare chicken broth. Cooking temperatures varying from 97 to 120°C.(207 to 248°F.) were tried. When temperatures were above 100°C.(212°F.) for any considerable length of time one could notice a typical "burnt" odor

[1] This basal was prepared by dissolving 1.5 cc. of four per cent Tartrazine, 0.6 cc. of four per cent Amaranth, and 0.04 cc. Fast Green FCF in 100 cc. H_2O.

in the broth; this "burnt" odor became concentrated in further fractionation, so elevated temperatures had to be avoided.

A gentle simmering of whole chicken carcasses in tap water for 24 hours produced the highest quality broth. No salt was added, though the addition of salt in one sample seemed to produce a more pronounced odor of chicken during cooking of the broth. It did not, however, give a greater yield upon separation. Removal of the kidneys, lungs, and preen gland during dressing seemed to have no effect on the flavor.

In the preparation of the broth approximately 10 pounds of chicken and 10 pounds of water were simmered in a stainless steel, hot-water jacketed kettle. After 48 hours, when the broth was drawn off, the flavor in the meat was nearly gone. Further cooking only produced a very weak broth.

Experiment No. 4. *Separation of Odoriferous Substances From Broth*

Two ways were used to remove flavoring material from the broth. One made use of a flash concentrator of the type developed by Bartholomew (1949), the other was a low pressure steam distillation which might be described as a water-distillation by essential oil chemists, Guenther (1949).

For use in the flash still (sometimes called a steam stripper), the broth was allowed to stand until any fatty type material came to the surface, then the water-soluble layer was drawn off and filtered through glass wool. This broth was run through the stripper; only the volatile portion was collected. A good concentration and separation of the flavor was effected except for one fault: the gelatin tended to gum up the concentrator. This could be avoided only by very careful removal of the fat and use of very hot solutions to avoid hardening of the gelatin.

Essentially the same separation could be obtained by use of steam distillation. The disadvantage in this procedure was that the volume of distillate became very great in exhaustion of flavor from the broth.

When pressures of steam higher than five pounds were used, the flavor was burned owing to overheating in the retort.

The fact that the flavor could be distilled illustrates that MSG (monosodium glutamate) and related compounds are not completely responsible for chicken broth flavor. Monosodium glutamate cannot be steam distilled. This fact can be further illustrated by a simple experiment.

Four samples were submitted to a taste panel for scoring: Pure MSG (one per cent); mild chicken broth [2] (diluted by N. content to equal one per cent MSG); steam distillate of chicken broth; and steam distillate of chicken broth, plus one per cent MSG. Results of the scoring are shown (Table 1).

Experiment No. 5. *Concentration of the Primary Distillate*

Since the flavor was extremely volatile once it was separated from the broth, subsequent concentration had to be carried on at atmospheric pressures. A still with a reflux fractionating head was used for this operation. The column used was a Bruun type, bubble-cap column. Distillation was

[2] The MSG content of chicken broth was not determined.

TABLE 1

Illustrating Importance of the Volatile Compounds in Flavor of Chicken Broth

	One per cent MSG plus steam distillate	Pure MSG one per cent	Pure broth	Pure steam distillate
Odor by sniffing	Distinct odor of chicken	No odor	Strong odor of chicken	Distinct odor of chicken
Taste by holding the nose	Fairly strong bouillon taste	Strong bouillon taste	Strong bouillon taste	Very mild sensation type "flavor"

effected at temperatures close to 100°C.(212°F.). Each run through this type of column, collecting 10 per cent of the volume, produced a concentration of 10 times. Use of vacuum in this type of still incurred severe loss owing to the high volatility of the flavor after being fractionated. Upon repeated concentration of this material a flavoring material was produced which was 10,000 times as strong as the original broth undeveloped. It existed in a clear solution, with an ammonia or amine-like odor. When the solution was developed by addition of a little monobasic potassium phosphate, the flavor of chicken was so strong it was nauseating. A more appetizing flavor was evident upon dilution. Its keeping properties were very poor; it could be either oxidized or reduced by contact with the air. Concentrates could be kept for considerable periods at temperatures below —103°F. (dry ice).

SUMMARY

The flavor of chicken consists of volatile compounds which are sufficiently stable to be stripped from a broth and concentrated in a fractionating column. These volatile compounds can be used in a synthetic "basal" to produce a broth indistinguishable by sensory perceptions from natural chicken broth. The concentrate can be used to determine chemical properties of the flavor.

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GROWTH RESPONSE OF FOLIC ACID-DEPLETED RATS TO SUPPLEMENTATION WITH TROPICAL FOODS

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Young rats fed a folic acid-free ration, containing two per cent succinylsulfathiazole (SST), are known to develop deficiency signs, such as cessation of growth, leukopenia, alopecia, and, in a high percentage of the animals, infarction of the spleen, in a period of from three to four weeks. Administration of synthetic folic acid to the depleted animal has been shown by Asenjo (1948) to induce a remission of the deficiency symptoms at a rate that is roughly proportional, within certain limits, to the level of synthetic folic acid administered.

In the following experiments we have attempted to estimate the folic acid activity of several foodstuffs, especially that of tropical legumes and fruits, by comparing the growth response induced by them and by synthetic folic acid when fed as supplement to depleted rats. Records were also kept of the food consumption, white cell count, alopecia rating, and spleen morphology at the end of the supplementation period. However, a full discussion of that data will be published elsewhere. Under the conditions of our experiment, these other indexes, although they were less consistent and steady in their response than the growth rate, also varied in proportion to the level of folic acid administered as supplement.

EXPERIMENTAL PROCEDURE

Twenty-one-day-old Wister albino rats from our colony were kept in cages with raised wire floors, three to a cage. The basal purified diet free of folic acid, fed *ad libitum*, had the following composition per kg.: sucrose, 599 gm.; vitamin-free casein, 180 gm.; salt mixture, 40 gm.; cellu flour, 40 gm.; hydrogenated vegetable oil, 100 gm.; corn oil, 20 gm. (containing 52,000 I. U. vitamin A, 13,000 I. U. vitamin D, and 32 mg. α-tocopherol); succinylsulfathiazole, 20 gm.; choline chloride, one gm.; inositol, eight mg.; nicotinic acid, 40 mg.; calcium pantothenate, 44 mg.; thiamine hydrochloride, eight mg.; riboflavin, 16 mg.; pyridoxine hydrochloride, eight mg.; p-aminobenzoic acid, four mg.; biotin,[1] 0.5 mg.; 2-methyl-1,4-napthoquinone, 10 mg. The depletion period ranged from three to four weeks. By the end of the fourth week the majority of the animals had reached a weight plateau and a white cell count of 3,000 to 4,000 cells per mm.^{3} and then the depleted animals were placed in indi-

[1] Biotin supplied by Hoffmann La Roche, courtesy of Dr. E. Sevringhaus.

vidual cages. The supplementation period lasted five weeks, during which time the animals continued receiving the basal diet *ad libitum*; that is, from the time they were seven weeks old, when they were depleted, to their 12th week of growth. The supplement was fed daily in a separate dish, six times per week, mixed with two per cent of SST. Those animals that died during the first five days of supplementation were considered overdepleted and were discarded.

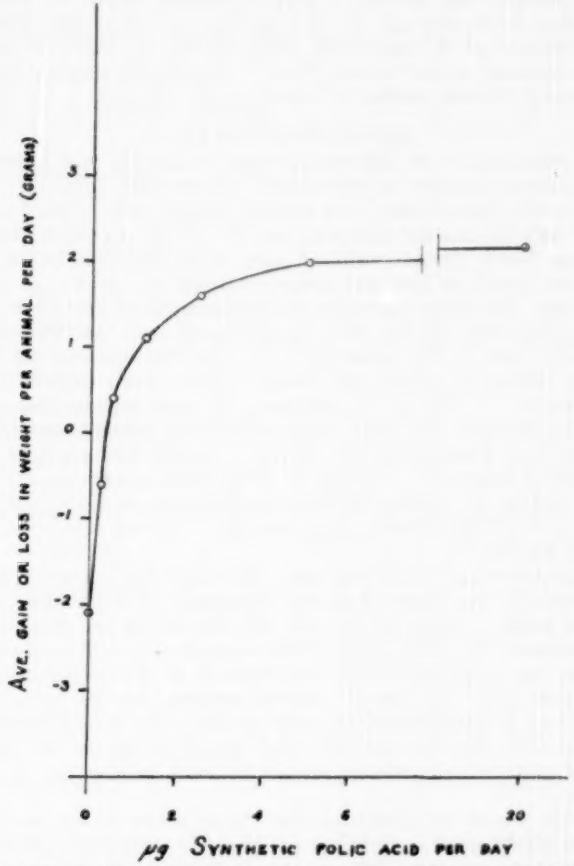

FIG. 1. Average gain or loss in weight per rat per day of folic acid-depleted animals supplemented with different levels of synthetic folic acid.

For a reliable assay it was desirable to establish a calibration curve with synthetic folic acid. Groups of 12 rats (of nearly equal numbers of males and females) were fed 0.00, 0.25, 0.5, 1.25, 2.50, 5.00, and 20.00 μg.

of synthetic folic acid in the form of its sodium salt. In the groups receiving the natural products, a nearly equal number of males and females was also used. Weekly records were kept of the weight of all rats. The maximum amount of supplement fed to the animals was two gm., so as not to interfere significantly with the basal diet intake. If the animals showed a growth response at the two-gm. level of supplementation, above that obtained with five μg. of folic acid, then lower levels were fed until one was reached that induced a growth response within the values obtained when 0.5 to five μg. of synthetic folic acid were fed. The intermediate segment of the calibration curve was the one chosen to make the readings, because, as can be seen (Fig. 1), it is in this range of the curve that the most reliable conversion values can be obtained.

RESULTS AND DISCUSSION

The responses of the different groups of animals that received the various natural products as supplement are recorded (Table 1).

Among the concentrated foods studied, *Torula* yeast [2] proved to be the material with the greatest folic acid activity (10 μg. per gm.). Next came red kidney beans, pigeon peas, and navy beans, with five to 4.0 μg. per gm. Dried breadfruit seed and black beans had 1.6 and 0.5 μg. per gm., respectively. The other concentrated foods assayed all proved to be very poor in folic acid activity. It is interesting to note that whole-powder-dried-milk is low in folic acid activity, a fact that confirms the findings made by Day *et al.* (1946) and Hodson (1949), using methods different from ours. The mixture of rice and beans, the most popular dish and represents the backbone of Puerto Rican rural diet, Descartes *et al.* (1941), were both very low in folic acid activity, a finding that might be of some local medical importance. Among the fresh fruits and greens studied, the avocado and the lettuce were the only ones to exhibit an appreciable amount of folic acid activity (about one μg. per gm.); the rest all proved to have very low activity.

It is interesting to note that many of the products assayed, when fed at the two-gm. level, induced growth responses well above those obtained with the largest dosage of folic acid fed, that is, 20 μg. However, these same products when fed at lower levels induced an overdiminished growth response, not in proportion to that obtained at the higher levels. This suggests the possibility that the growth response observed on feeding the higher levels of natural products could be due not only to a supplementation with folic acid but also with other factor, or factors, needed by the depleted animals and perhaps present in small amounts in the natural materials.

In this respect we should consider the adequacy of our basal diet in interpreting the results. Although this diet was complete in all the known nutritional requirements of the rat, except folic acid, there is a possibility, since it was fed admixed with an inhibitor, that the animals thus treated could have developed in addition to an acute deficiency of folic acid, a milder deficiency or deficiencies of one or more unknown factors. *Torula*

[2] Provided by The Puerto Rico Industrial Development Co.

TABLE 1

Growth Response of Rats Receiving Different Food Products

Supplement	Level of supplement fed per day	No. of animals	Av. survival on supplement	Av. gain or loss in weight	Estimated folic acid
	gm.		*days*	*gm./day*	*µg./gm.*
Concentrated foods					
Dried *Torula* yeast	2.0	3	35	3.4	.....
	0.5	3	35	2.9	.....
	0.2	11	30	1.4	10.0
Red kidney beans[1] (*Phaseolus vulgaris* L.)	2.0	2	35	2.8	.....
	1.0	9	29	2.0	5.0
Pigeon peas[1] (*Cajan Cajan* [L] Millsp.)	2.0	3	35	2.6	.....
	0.6	19	33	1.6	4.2
Navy beans[1] (*Phaseolus vulgaris* L.)	2.0	3	35	2.4	.....
	0.8	7	29	1.6	3.1
Breadfruit seed[1] (*Artocarpus integrifolia* L.)	2.0	3	35	1.6	.....
	0.8	6	31	1.2	1.9
Black beans[1] (*Dolichos Lablab* L.)	2.0	3	26	3.3	.....
	1.0	7	26	0.3	0.5
Whole dried milk	2.0	10	25	0.9	0.5
Dried polished rice $\frac{2}{3}$, red kidney beans[1] $\frac{1}{3}$	2.0	9	26	0.5	0.3
Polished rice	2.0	6	23	0.4	0.2
Basic Puerto Rican rural diet (dried)	2.0	10	26	−0.1	<0.2
Fresh fruits and greens					
Avocado (*Persea gratissima* L.)	2.0	6	35	1.1	0.7
	1.0	6	35	1.0	1.1
	0.5	6	23	0.7	1.4
Lettuce (*Lactuca sativa* L.)	2.0	3	35	1.4	1.0
Dried coconut meat (*Cocos mucifera* L.)	2.0	5	30	0.8	0.5
Mango (*Mangifera indica* L.)	2.0	3	24	−0.1	<0.2
Okra (*Abelmoschus esculentus* L.)	2.0	3	23	−0.4	<0.2
Pineapple (*Bromelia ananas* L.)	2.0	4	14	−0.4	<0.2
Mesple (*Sapota achras* Mill.)	2.0	3	16	−0.8	<0.2
Custard apple (*Annona reticulata* L.)	2.0	3	21	−0.9	<0.2

[1] Fed boiled and dried.

yeast, red kidney beans, pigeon peas, and some of the other natural products that, at the lower levels of supplementation exhibited an overreduced response, are possible carriers of this factor or factors when fed at higher levels. The figures for folic acid reported (Table 1) are, therefore, not intended to be absolute and final values, although they do represent, under the conditions of this experiment, the relative over-all activity these foods have in inducing weight responses in rats totally depleted of folic acid and perhaps suffering also, in a mild way, from other unknown deficiencies.

SUMMARY AND CONCLUSIONS

By comparing the growth response, in folic acid-depleted rats, induced by daily supplementation of graded levels of synthetic folic acid and of different food products, during a period of five weeks, the folic acid-like activity of the latter was estimated.

Torula yeast, legumes in general, breadfruit seed, and among the fresh products, avocado and lettuce, proved to be good sources of folic acid-like activity, while coconut meat, dried whole milk, rice and beans mixture, polished rice, the basic Puerto Rican rural diet, mango, okra, pineapple, mesple, and custard apple were poor sources.

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OBSERVATIONS ON SLOUGHING OF POTATOES

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Variable cooking quality is a common fault of potatoes as marketed for food. Some tubers boil to pieces or slough excessively, others remain mealy but coherent, still others are rubbery or waxy. Although there are definite uses for each type of tuber, the disadvantages of marketing all types in the same package are obvious. Furthermore, considerable variation in texture occurs in different lots of tubers intended for the same use.

Efforts to increase uniformity in texture have been directed, in general, either to perfecting means for selecting tubers of uniform texture or to developing methods for modifying and controlling tissue texture. The association of high specific gravity (or high starch content) with mealiness of tubers has been noted by Coudon and Bussard (1897), Cobb (1935), Sweetman (1936), Wright, Peacock, Whiteman, and Whiteman (1936), Bewell (1937), Haddock and Blood (1939), Clark, Lombard, and Whiteman (1940), Smith and Nash (1940), Prince, Blood, Coates, and Phillips (1940), and others. In many cases, therefore, it has been possible to select tubers of similar texture from mixed lots by differential flotation of tubers in solutions of appropriate specific gravity. Because of the correlation between mealiness and sloughing, Sweetman (1936) and Barmore (1938), the specific gravity method should be useful also for separating tubers that will slough from those that will remain whole on boiling.

The texture of cooked potatoes and potato products may be altered by the addition of calcium salts, Personius and Sharp (1939), Pyke and Johnson (1940), Barker and Burton (1944), and Rhodes and Davies (1945). Although the use of calcium salts for this purpose has not been widespread in this country, the U. S. Food and Drug Administration has recently (Federal Register, May 10, 1949) approved the use of several calcium salts in the canning of potatoes. It is apparent, although seldom recognized, that the natural hardness of the water used in processing potatoes affects their texture.

In the present paper data are presented that illustrate variability in the degree of sloughing within the same lot and between different lots of tubers. Efforts were made to account for the variability, and thus to provide a basis for control of sloughing, by studying the relationships between sloughing and specific gravity, starch content, calcium ion concentration, tissue heterogeneity, potato variety, and tuber storage conditions.

EXPERIMENTAL PROCEDURE

The method used for measuring the extent of sloughing was somewhat similar to that employed by Barmore (1938) and Pyke and Johnson (1940).

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Approximate cubes of 10 gm. each were cut from peeled tubers. The cubes were boiled gently in beakers for 30 minutes, in twice their weight of liquid (usually distilled water). When cool, the cubes and liquid were poured into a wire basket of one-quarter-inch mesh, partly immersed in water. The basket was lifted, then re-immersed 10 times in order to wash free and collect the loosened, or sloughed, pieces of tissue. These were dried to constant weight at 80°C.(176°F.). The percentage sloughing losses reported are on the dry weight basis. Specific gravity determinations were made by flotation of tubers and tissues in brine. After the density measurement, the cut tissues were quickly and thoroughly rinsed in distilled water.

RESULTS

Variation in Specific Gravity: Preliminary experiments with five lots of U. S. No. 1 potatoes showed there was considerable variation in amount of sloughing, both within the same lot of tubers and between different lots. In all lots there were some tubers which showed no breakdown at all, and other tubers which sloughed excessively. However, the proportion of tubers which sloughed varied from lot to lot, being highest in the lot of highest average specific gravity (Green Mountain variety, grown on Long Island) and less in lots of low average specific gravity. Distribution in the specific gravity of tubers in the five lots, which indicated approximately the proportion of tubers in each lot which sloughed, is shown (Table 1). The data are from 60 to 100 pounds of potatoes in each lot. Tubers

TABLE 1

Distribution in Specific Gravity of Potato Samples

Approximate specific gravity	Per cent of tubers by weight				
	Green Mtn., L. I.	Green Mtn.,[1] Me.	Katahdin, Pa.	Katahdin,[1] Me.	Chippewa,[1] Me.
1.075 and less	10	59	64	68	49
1.080	....	23	11	15	49
1.085	16[2]	12	18	10	2
1.090	....	5	4	6	....
1.095	35	1	2	2	....
1.100	27	....	2	....	....
1.105	13	....	....	....	....

[1] These potatoes were obtained from the Maine Experiment Station, Presque Isle, through the courtesy of F. W. Griffee. The other potatoes were commercial samples, the Katahdins from Schnecksville, Pennsylvania, the Green Mountains from Riverhead, Long Island, New York. [2] This figure is the total for the specific gravity groups 1.080 to 1.090, inclusive.

of specific gravity 1.075 and less did not slough. The two lots of Green Mountain potatoes (from Long Island and Maine) differed widely in distribution of specific gravity, but the three lots from Maine (Katahdin, Chippewa, and Green Mountain) were similar. There was a greater difference within a variety than between varieties.

Variation in specific gravity within a single tuber (which indicated at least roughly the variation in extent of sloughing in different parts of the tuber) was also considerable (Fig. 1). In general, tissues of highest specific gravity occurred on both sides of the vascular ring (near the tuber periphery), and tissues of lowest specific gravity were in the central pith

or medulla and in the immediate vicinity of buds and the tuber stalk. The starch content [estimated from the specific gravity-starch content data of von Scheele, Svensson, and Rasmusson (1937)] ranged from about 10 per cent on the fresh basis in the central pith, to about 25 per cent in parts of the peripheral zone. Similar patterns of distribution were obtained from tubers of different average density, variety, shape, and size, although small tubers tended to have a more uniform distribution than large tubers.

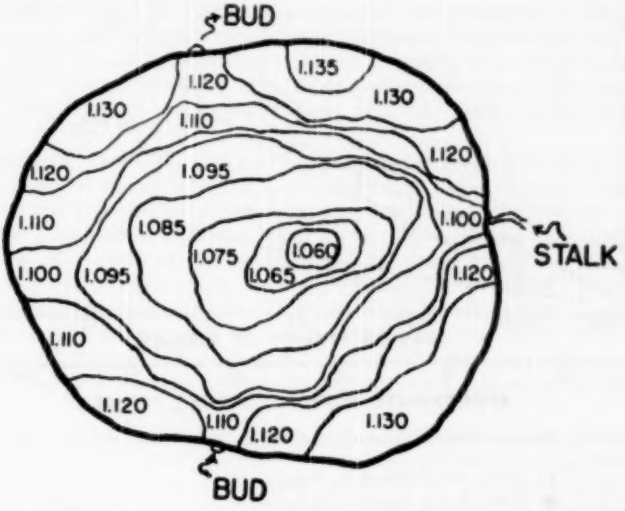

FIG. 1. Radial longitudinal section of Green Mountain tuber of specific gravity 1.105, showing the specific gravity of tissues in different regions. The extent of sloughing might be expected to range from about 35 per cent in the zone of specific gravity 1.135, to almost none in zones of specific gravity 1.075 and less.

Frequently the region of maximum specific gravity was five to 10 mm. inside the skin or periderm, midway between the stalk and tip ends of the tuber; in other tubers the densest region occurred within the first five mm. from the skin. Specific gravity of tissues on opposite sides of the same tuber often was not the same. Tubers of high specific gravity usually had a wider cortex than those of low specific gravity. These observations on variability in specific gravity showed why the use of whole tubers would not give reliable data on the relation between specific gravity and sloughing. Rather, the selection of small pieces of tissue of more uniform specific gravity was suggested.

Relation Between Specific Gravity, Variety, and Sloughing: How the mean sloughing loss from tissue cubes changed with specific gravity is shown (Fig. 2). The cubes (10 gm. each) were taken from a number of tuber lots, previously subjected to commercial cool storage for from one to three months, then held at 20 to 23°C.(68 to 73°F.) for two or more

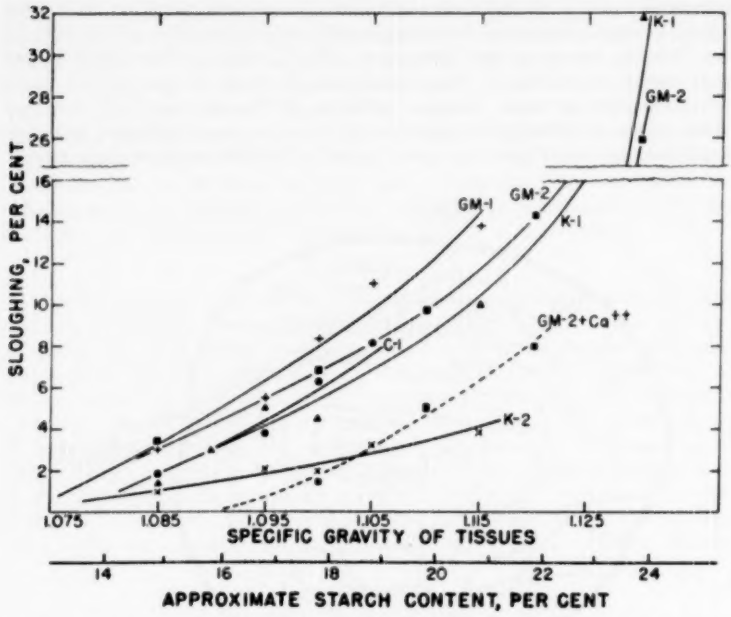

FIG. 2. Relation between sloughing and specific gravity, variety, and calcium ion treatment.

+ GM-1. Green Mountain, Maine.
■ GM-2. Green Mountain, Long Island.
■ GM-2+Ca^{++}. Green Mountain, Long Island, boiled in 0.014 N Ca^{++}.
▲ K-1. Katahdin, Pennsylvania.
× K-2. Katahdin, Maine.
● C-1. Chippewa, Maine.

The approximate starch content corresponding to the specific gravity of the tissues is from von Scheele *et al.* (1937).

weeks. The specific gravity of each cube was measured, after which five or 10 cubes of the same specific gravity from the same lot of tubers were pooled for determination of their sloughing loss. In most cases, from 20 to 100 cubes were used for each specific gravity level in each lot. The reliability of the data is indicated by the standard error of the sloughing values for the Green Mountain tubers (GM-2, Fig. 2). For the samples whose mean sloughing loss was 6.7, 9.6, 14.1, and 25.7 per cent, the respective standard error was 0.5, 1.0, 1.1, and 3.6 per cent.

The relationship between specific gravity and sloughing was general, although somewhat imperfect. Within each variety or lot, a significant increase in sloughing paralleled an increase in specific gravity. At the same specific gravity level, however, there were differences in the sloughing loss between varieties and between different lots of the same variety.

Especially outstanding and statistically significant was the low degree of sloughing of the Maine-grown Katahdin (K-2, Fig. 2). Among the other lots, differences in degree of sloughing were relatively slight. The two lots of Green Mountain tubers sloughed somewhat more than did the Chippewa and Pennsylvania-grown Katahdin potatoes, although at the highest density level the sloughing loss from the latter lot exceeded that from the Long Island Green Mountain variety. Since none of the lots from Maine (Green Mountain, Chippewa, and Katahdin) contained tissues of very high density, determination of sloughing losses in these lots was restricted to relatively low density tissues. These data on sloughing losses obviously are not complete enough to characterize generally the tubers of a particular variety, locality, or storage condition. Sloughing losses from tissue cubes usually were less than losses from quartered tubers of the same average but less uniform density.

Additional data were obtained to elaborate on variability in sloughing from tissues of the same density. Not only was there variation between different lots and between different tubers of the same lot but also between different tissue cubes from the same tuber. For example, the sloughing loss from nine cubes of specific gravity 1.120 from one Green Mountain tuber ranged from five to 29 per cent. Subdivision of one of the 10-gm. cubes gave eight cubes of about 1.25 gm. each, which ranged in specific gravity from 1.095 to 1.130, and in sloughing loss from seven to 53 per cent. In this manner it was possible to detect differences in sloughing that would be masked if large numbers of tissue segments were combined before testing.

Further studies are in progress to account for variation in sloughing from tissues of the same density. Apparently, an understanding of the causes for variation in a single tuber is equivalent to understanding the general problem of sloughing. It is likely that variations in the distribution of dense areas are responsible in part for the observed differences in extent of sloughing. Furthermore, there is a tendency for cubes from the center periphery of a tuber to slough more than cubes of similar density from either the base or tip periphery region. Finally, the differences in some cases may be associated with differences in the starch content of tissues of the same density (as suggested by the data of Table 2, following section of this paper).

In these experiments the specific gravity of each cube was determined within about one minute after it was cut. Immersion of the cube in brine for more than a few minutes increased its specific gravity. Thin-peeled, whole tubers were slightly more dense than unpeeled tubers, owing principally to the gas trapped in the skin cork. The effect of the skin on specific gravity was, of course, most pronounced in the smallest tubers.

Changes in Sloughing Associated With Storage: It has been reported, Rathsack (1935), Barmore (1938), Pyke and Johnson (1940), and Federal Register (1949), that the tendency of potatoes to slough decreases during storage. Additional data on this subject were obtained from experiments with the Long Island Green Mountain potatoes. After being in commercial cool storage for about three months following harvest, the potatoes were

kept at 20 to 23°C.(68 to 73°F.) for from two to three weeks. The mean extent of sloughing of cubes (sp. gr. 1.130) from tubes of specific gravity 1.105 was then 26 per cent. After three months' additional storage at 1°C. (34°F.) the amount of sloughing decreased to six per cent. However, after storage again at 23°C.(73°F.) for two weeks the amount increased to 15 per cent. Specific gravity of the tubers meanwhile remained the same. Similar results were obtained with other tubers and cubes of different specific gravity.

Observations on the dependence of the specific gravity-sloughing relationship upon the duration and temperature of storage are summarized (Table 2). It shows also the changes in starch content during storage.

TABLE 2

Effect of Storage Temperature on Starch Content, Extent of Sloughing, and Specific Gravity of Tissue Cubes From Long Island Green Mountain Potatoes

Storage conditions of tubers	Approximate specific gravity of cubes	Starch content by chemical analysis, wet basis	Sloughing loss, dry basis
		pct.	*pct.*
Period A. Commercial cold storage three months, then two to three weeks at 20 to 23°C.(68 to 73°F.).	1.130	.....	26
	1.120	.....	14
	1.110	.....	10
	1.085	.....	3
	1.075	.....	1
Period A plus three months at 1°C.(34°F.).	1.130	17.2	6
	1.120	13.4	2
	1.110	12.1	1
	1.085	7.0	....
	1.075	5.1	<1
Period A plus two and one-half months at 1°C. (34°F.); then two weeks at 23°C.(73°F.).	1.130	19.7	15
	1.120	17.6	9
	1.110	.....	3
	1.085	10.6	....
	1.075	8.0	1

Starch analyses were made by C. O. Willits and associates, by the method of Clendenning (1945). As the starch content fell and rose during storage, the extent of sloughing changed correspondingly. Wright *et al.* (1936) found that storage under conditions such that excessive hydrolysis of starch to sugar occurred, resulted in the potatoes being soggy. Studies concerning the relation between starch content and sloughing, and concerning the inadequacy of the specific gravity method for predetermining the sloughing characteristics of tubers, are being continued.

Control of Sloughing by Calcium Ion: The effectiveness of a low concentration of calcium ions in reducing sloughing at different density levels in Green Mountain potatoes is shown (Fig. 2). Tissue cubes were boiled without previous soaking in a solution of 0.014 N calcium sulfate, equivalent to 0.095 per cent calcium sulfate, or 0.028 per cent calcium ion. The presence or absence of 0.3 per cent sodium chloride in the solution made little difference in sloughing loss. The calcium reduced sloughing at all

density levels, although at the higher density levels the extent of sloughing (about half of the original extent) remained excessive. In the latter cases, however, sloughing was reduced further and controlled adequately by using higher concentrations of calcium salts (0.03 to 0.06 N). An original solution of 0.06 N calcium salt yields a concentration of calcium in a canned product (potato tissue two parts, liquid one part) which is below the maximum permitted by law (0.051 per cent). The limited solubility of calcium sulfate restricted its use for controlling sloughing in extreme cases. This salt, in combination with sodium chloride, is available commercially in convenient tablet form, Martin and Braun (1948). Other salts, such as calcium chloride, calcium lactate, calcium gluconate, and potassium alum were almost equally effective in reducing sloughing, and none of the salts at the concentrations used impaired the potato flavor.

Subjective observation indicated that calcium ion might differ in its effect upon tissue texture, depending upon potato variety, density of tissues, and concentration of calcium. Treated tissues from Katahdin potatoes often were surface-toughened, whereas no such toughening was observed with Green Mountain tissues at the same calcium level. Surface toughening usually was more pronounced in tissues of low density than in those of high density. Lowering the concentration of calcium diminished the extent of surface toughening. For canned apples, Hills, Nevin, and Heller (1947) found that the degree of surface toughening brought about by calcium treatment gradually decreased during storage.

The control of potato tissue texture by means of calcium salts is demonstrably of commercial value, Rhodes and Davies (1945) and Federal Register (1949). Reduction in extent of sloughing is accompanied by a marked increase in clarity of the liquid phase, which improves the appearance of the canned product. In some cases untreated tubers break down into a pulp following a cooking period of five or six minutes only, whereas appropriately treated tubers remain whole and of good appearance. Since calcium salts not only inhibit sloughing but also increase tissue firmness (by about 30 per cent with 0.06 N calcium chloride, as we have found by measuring the compressibility of tissues), treated samples should show less breakdown during shipping and handling.

DISCUSSION

Sloughing of potato tissues during cooking results from the rounding off and separation of starch-filled cells and cell clusters. In waxy or soggy tissues the cells show less rounding and remain firmly stuck together. Cells separate (they seldom rupture) because of the failure of the intercellular cement, which is composed of pectic compounds. It is natural, therefore, that many workers, Davison and Willaman (1927), Dastur and Agnihotri (1934), Sweetman (1936), Barmore (1937), Personius and Sharp (1939), Freeman and Ritchie (1940), Pyke and Johnson (1940), and others, have looked for a relationship between pectins and potato tissue texture. Yet the observed changes in texture cannot be adequately explained in terms of changes in pectins alone. Failure of the intercellular cement may be brought about either by chemical changes in the pectic compounds, by

mechanical fracture due to pressure developed in the cells and tissues, or by a combination of the two means.

In potato tissues pressure develops as starch granules within cells swell and gelatinize. The pressure increases with increased starch concentration and swelling. Agents such as calcium ion and other electrolytes that decrease the swelling of starch, Ripperton (1931), Wiegel (1934), and Nutting and Whittenberger (1949), should decrease the pressure and lessen the tendency for the cells to separate or slough. The presence of sugars, developed during cold storage, also decreases the tendency of the granules to swell, Whittenberger and Nutting (1948). Wilting of tubers might be expected to have a similar effect upon granule swelling. It is possible, therefore, to account in this manner for the correlation between starch content and sloughing, for the changes in sloughing associated with storage, and in part for the effect of calcium ion upon sloughing.

SUMMARY

A general relationship between the extent of sloughing from boiled potatoes and the specific gravity of raw tissues was observed. The scope of this relationship was studied by noting the conditions under which it applied best and under which it was of limited validity. Considerable variation both in extent of sloughing and in specific gravity occurred in different regions of the same tuber, in different tubers of the same lot, and in different lots of the same variety. Within the same lot of tubers, irrespective of variety or place of origin, tissues of highest specific gravity exhibited the greatest degree of sloughing, whereas those of low specific gravity (1.075 and less) did not slough. It was thus possible to separate the tubers into groups of fairly uniform cooking characteristics by means of differences in their specific gravity. However, tissues of the same specific gravity from different lots of tubers did not always slough to the same degree. Moreover, the degree of sloughing from tubers of the same lot varied with temperature of storage, although the specific gravity of the tubers remained essentially unchanged. In the latter case the degree of sloughing varied with changes in the starch content. The use of calcium salts, in concentration less than the United States legal maximum for canned potatoes, adequately controlled sloughing in all samples and increased the firmness of tissues. The principal cause for sloughing is thought to be associated with the swelling capacity of starch during gelatinization, which develops pressure within cells sufficient to fracture mechanically the intercellular cement.

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SURVIVAL OF *SALMONELLAE* IN BOILED DUCKS' EGGS

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It is common knowledge that ducks' eggs occasionally contain *Salmonellae*, which may constitute a health hazard to the consumer. The Netherlands' Government, therefore, advises a boiling-time of 10 minutes. We have investigated the course of the temperature in the egg during the boiling process and its connection with the destruction of the *bacilli*. The following technique has been used:

The eggs are infected by injecting into the yolk cultures 0.2 ml. of a mixture of one- and three-day broth cultures grown at 37°C.(99°F.) and containing approximately 100,000,000 *Salmonella typhi murium* and *Salmonella enteritidis* organisms, isolated from naturally infected ducks' eggs. The eggs are kept in an ice water bath at 0°C.(32°F.) for at least one hour, in order to cool the center to that same temperature. They are then immersed in boiling water and when taken out of the boiling water, the bacteriological test is commenced.

TABLE 1

Ducks' Eggs [Temperature 0°C.(32°F.)] Immersed in Boiling Water

No. eggs examined	Diameter	Wt.	Boiling-time	No. eggs containing viable *Salmonellae*	
				Present	Absent
	mm.	*gm.*	*min.*		
19	42-47	57-75	10	19	0
5	45-46	66-76	11	5	0
15	45-46	64-80	12	0	15
15	47	71-80	12	6	9
8	46	71-83	13	0	8
19	47	69-85	13	1 (wt. 85 gm.)	18
3	48	77-84	13	1 (wt. 84 gm.)	2
36	47-50	80-105	14	0	36

RESULTS

The table shows that a boiling-time of 10, 11, or 12 minutes is insufficient to kill all *Salmonellae*. Even after 13 minutes, viable *bacilli* are still present in big eggs (diameter 47 and 48 mm.). After 14 minutes' boiling, however, all *bacilli* are killed, even in the biggest and heaviest eggs on the market.

In order to explain these results, the temperature inside the egg was measured by means of a thermocouple, consisting of thin constantan and steel wires. One point of contact, the end of a steel needle, was placed in the center of the egg, the other kept at a fixed, known temperature. Temperature differences were read from a millivolt meter. Our experi-

ments have shown that after 10 minutes' boiling (as advised by the Government) the temperature at the center is still under 50°C.(122°F.) (Fig. 1). Curve *a* shows the rise in temperature of the center if the egg

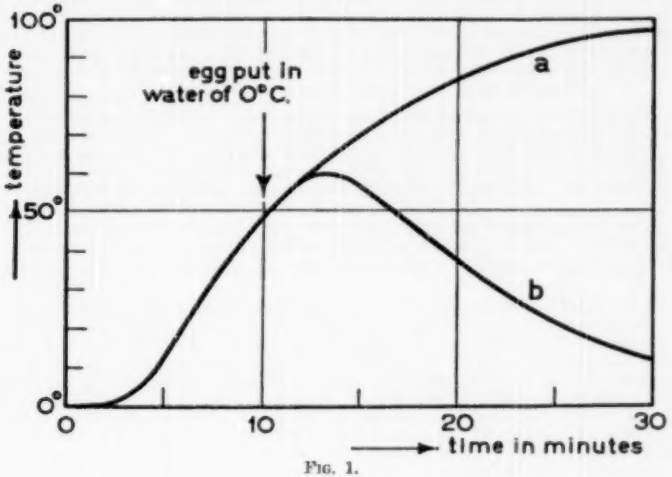

FIG. 1.

is kept in boiling water 30 minutes. Its shape may be explained by assuming that the thermal conductivity of egg substance is slightly less than that of water. Bearing in mind the high water content of egg white and yolk, this does, indeed, seem plausible. It is interesting to note that the thermal conductivity of unboiled and hard-boiled eggs is the same. Coagulation, therefore, does not alter the thermal conduction.

Considering these results, it is not surprising that live *Salmonellae* are still present in 46-mm. eggs, boiled for 11 minutes. They are killed when the center of the egg has reached a temperature of 59 to 60°C.(138 to 140°F.).

From a practical point of view, it is important that the temperature of the center continue to rise after the boiling process, when the egg is cooled in the air or in cold water. If 10 minutes' boiling is followed by immersion in water of 0°C.(32°F.), the central temperature still rises 11°C.(52°F.) (Curve *b*), enough to kill the *Salmonellae*. Thus, strictly speaking, the destruction of the *bacilli* is caused in this case by the rise in temperature after the "boiling" and during the "cooling." If, however, the egg is eaten at once after 10 minutes' boiling, or its contents cooled down immediately by slicing or chopping, viable *Salmonellae* may be present and constitute a health hazard.

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